Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

ENERGY CONSERVATION IN CANADA:

Programs and Perspectives

Report EP 77-7

1977

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

ENERGY CONSERVATION IN CANADA:

Programs and Perspectives

Report EP 77-7 1977

Cat. No.: M23-12/77-7 ISBN–0-662-01358-1

Published by authority of
The Honourable Alastair Gillespie,
Minister of Energy, Mines and Resources,
Government of Canada

FOREWORD

It has been little more than a year since I announced in the House of Commons the first major steps of an energy conservation program in Canada. This was part of our overall *Energy Strategy for Canada* which we have called *Policies for Self-Reliance*. That strategy has two main thrusts, namely, to increase our domestic supply of energy and to reduce the rate of growth of energy use. This report focusses on the use, or demand, side. It starts with the assumption (which is demonstrated graphically in the *Energy Strategy* report) that the trend in energy use must be lowered substantially below that of the past decades, decades which saw a doubling of energy use every fifteen years. Indeed the rate of increase in energy use was so rapid in the 1950's and 1960's that the world consumed more energy in that period than in all previous history. The days of cheap energy, on which this trend was based, are gone. Neither crude oil nor natural gas will henceforth be available on such easy terms.

The report that follows serves to show how we can drastically reduce the rate of increase in our use of energy, in ways that will be as painless and as equitable as possible. The report sets out the opportunities for energy saving. It indicates, for the residential, commercial, industrial and transportation sectors, where we are indulging in wasteful energy-use habits fostered by relatively cheap energy over the past few decades. These are the sectors where there can be a dramatic payoff in terms of energy-saving by modest changes towards more energy-efficient practices.

There will undoubtedly be adjustment problems as the nation adapts to the new energy situation. In this report, a basis is laid for a program of action which can be effective in lowering energy use and reducing those problems, without detracting from (and possibly aiding) the achievement of other national goals. It would clearly not be the policy of the Government to promote an energy conservation program without considering its implications for other important issues such as employment and real income, or public safety and health.

Energy saving opportunities from various conservation measures are quantified in this report, to provide some sense of dimension of the possibilities that are economically and socially feasible and thereby support some of the key assumptions underlying the *Energy Strategy* report. That report set an average energy demand growth rate target of less than 3.5 per cent a year. The analysis of programs set forth in this report indicates that not only is 3.5 per cent clearly achievable, but, given the right combination of circumstances, an

average growth rate of 2 per cent in total primary energy consumption to 1990 is possible. The energy saving in 1990 resulting from a reduction in energy demand of this magnitude would be equivalent to the annual output of eleven Syncrude-size oil sands plants at a capital cost in excess of $30 billion. The actions required to achieve this growth rate include price changes, regulations, subsidies, and a readiness on the part of individuals and businesses to respond to voluntary programs; they do not necessitate a slowing of the rate of income growth or an increase in unemployment.

The usefulness of this report lies in its identification of specific conservation opportunities and ways of realizing them, and its quantification of the impact on demand of some of the more important and readily achievable measures. It also underlines the importance of continuing to look for further substantial conservation opportunities over the longer term.

My Department will continue to develop new conservation programs, in response to the future energy situation, both on our own and in concert with the provinces where so much of the constitutional authority for action in this policy area now rests. This report, as a guide to action, should help get us moving toward a more efficient society.

HONOURABLE ALASTAIR GILLESPIE
Minister of Energy, Mines and Resources

CONTENTS

Tables

Figures

Definitions

Secondary energy demand includes all energy actually used by energy consumers in its final form. For the projections quoted in this report, total secondary (end-use) demand is generally defined as the total of the four major end-use sectors (residential, commercial, industrial, transportation) only.

Primary energy demand is the total quantity of energy resources required to satisfy the domestic demand by the final consumer for energy products. It thus refers to the amount of energy used by the final consumer (secondary energy) plus all energy used by the energy supply industries (including distribution losses), and the conversion losses during electrical generation from fossil fuels. Hydro and nuclear electricity are also converted to an approximate fossil fuel equivalent in the gross primary demand figure.

Btu (British Thermal Unit) is the amount of heat required to raise the temperature of one pound of water 1°F and it equals 1,054.8 joules. It is used in this report to allow for comparison with the *Energy Strategy* report.

Quad is 1 quadrillion Btu (10^{15} Btu), equivalent to 172 million barrels of crude oil.

Chapter 1. INTRODUCTION

In the spring of 1976 the Government of Canada, in a major energy policy report, entitled *An Energy Strategy for Canada: Policies for Self-Reliance**, stated that the country's energy supply situation was deteriorating and that firm policy action would be required to lessen Canada's dependence on imported oil. Since that time the overall energy picture has not improved. Various combinations of lower than expected rates of discovery, delays in delivery systems, uncertainty about the availability of oil imports and capital constraints have hindered the expansion of supply of all forms of energy in Canada.

We face the eventual exhaustion of the world supply of non-renewable energy resources—primarily oil and gas—and the increased difficulty and cost of exploiting all major energy sources, including electricity. We also face the fact that our economy, social structure and lifestyle are highly dependent on oil and gas.

In the long run (beyond 1990) we, and the rest of the world, will have to accommodate ourselves to an energy regime based to a much greater extent on new primary sources. How we manage the transition to this new regime is a matter of grave concern and will be the subject of other studies. In this report the issue is *what we must do now* in order to maintain an acceptable economic and social structure during the next ten to fifteen years, keeping in mind the changes that must be set in motion for the longer term.

Two issues dominate:

- how can we economically maintain and increase our energy supplies in an environmentally and socially acceptable way?
- how can we increase the efficiency with which we use energy in order to reduce the rate of growth of our energy consumption in an environmentally and socially acceptable way?

This report is concerned only with the second of these—energy conservation.

Our actual energy consumption over the next several years will depend on the interaction of many economic, political and social variables both within Canada and throughout the world. Although increasing levels of energy usage over the past 50 years have produced many benefits to Canadians, we can no longer afford to maintain patterns of energy use, or to adopt technologies and designs, that were appropriate to a period of cheap and abundant energy. Our energy will be increasingly costly, and, if for no other reason than the inability to pay for it, we will be compelled to account for our use of it and use it more efficiently.

---

* *An Energy Strategy for Canada: Policies for Self-Reliance*, Department of Energy, Mines and Resources, Ottawa, Ontario, 1976. Referred to throughout this report as the *Energy Strategy* report.

Energy conservation is not just a federal government concern. It is a matter that must concern all levels of government as well as utilities, industry, community groups and each individual Canadian. Accordingly, this report, although concentrating on federal initiatives, reviews actions and programs that have been and could be implemented by all decision-makers concerned with energy use.

Scope of this Report

The term "energy conservation" is used widely to describe efforts to reduce the intensity of energy consumption from the levels experienced in the recent past. Present energy demand patterns reflect the established habits of individuals, industries and governments during a period of cheap energy. Now we must take all reasonable steps to eliminate what are currently wasteful uses of energy.

Energy conservation has been defined in many different ways, but always with the central idea that energy resources can be used more efficiently. Basically, this means accomplishing—on the basis of acceptable technical, economic and social criteria—a given task using fewer units of energy. A comprehensive definition, however, must also include alternative means of achieving desired ends, with the ultimate objective of maintaining or improving our overall welfare and quality of life while reducing our energy use to a more sustainable level.

For example, automobiles with increased energy-efficiency would allow the same amount of travel to be undertaken with the use of less energy. There are, however, even more energy efficient means of carrying out some of the functions currently performed by using the automobile; these means include the use of public transport or telecommunications. In these cases there are trade-offs with other factors such as time or convenience which are difficult to express in economic terms but which must be taken into account. Another important example is the matching of energy type to energy use. Thus, in the case of space heating, where the required temperatures rarely exceed 20°C, the use of solar energy and other lower grade energy sources such as thermal wastes from industrial, commercial and electricity generation sources needs to be seriously considered.

It is important to emphasize that the above definition explicitly recognizes that energy conservation should be pursued only to the extent that it can improve the overall social welfare of Canadians, taking into account the interests of future generations. It is not worth pursuing if it results in the wasteful or inefficient use of other valuable resources, nor if the less tangible sacrifices (costs) involved are considered greater than the benefits obtained.

This report centres around programs and opportunities for conservation between now and 1990 in the major end-use sectors—buildings (residential and commercial), transportation and industry. Realistically attainable savings have been estimated for conservation measures which are believed to be technically feasible, economically justified and considered socially acceptable. For the measures proposed here the overall benefits to Canadian society quite clearly outweigh the costs.

A number of other conservation measures or technologies are discussed but not quantified in this study, since further research is necessary before quantification of their impact is possible. One important example is the cogeneration of heat and electricity, which is believed to offer a major potential for the more efficient use of energy. Future work will help to quantify this potential and identify the barriers to its attainment. Other examples include the design of urban areas, alternative agricultural practices, and so on, all of which deserve more study.

In this report, the estimated savings from the implementation of a number of conservation measures are used to develop a single conservation scenario, which is based on the same set of socio-economic assumptions (population, economic growth, energy prices) as the "high price - low economic growth" scenario presented in the *Energy Strategy* report. It should be made clear, however, that if the economy or population expands faster than assumed in that earlier analysis, the overall energy growth rate is likely to be greater, despite the probable achievement of higher energy savings.

In the case of some conservation measures, such as those involving the automobile, the impact on particular fuels can be identified but in general the impact of conservation measures is interpreted in terms of a reduction in total energy use rather than in a particular source of supply (oil, gas, coal, etc.). Inter-fuel substitution may be required to promote relatively greater conservation of particular sources of energy but, although such substitution will have extremely important implications, it is not within the scope of this report.

Although very important for long-term sustainability of energy supplies and demands, the active* use of renewable energy resources is not discussed here for two reasons. First, over the next fifteen years renewable sources are likely to make a relatively small impact on total energy consumption in Canada. Secondly, active uses of renewable energy are generally treated as methods of augmenting energy supply rather than reducing energy demand.

Impact of Energy Conservation on Canadian Society

The level of energy consumption in Canada depends on or is closely related to almost every other issue of economic or social significance. The complex interrelationships among all these factors dictate that conservation cannot be pursued in isolation. The most desirable energy policy will enable Canadians to optimize their welfare while recognizing the needs of other nations and of future generations.

In determining energy policy it is important to recognize that satisfying any particular goal can make the attainment of other goals more difficult. Trade-offs will be required and priorities will have to be set. Because of their

* The *active* use of, for example, solar energy refers to various techniques of capturing, storing and using the sun's rays for heat or electricity. This is distinguished from *passive* use, which includes building orientation, window design, etc., to make best use of (or reduce conflict with) direct solar impact. Passive use of the sun or wind is considered a conservation measure.

potential importance, a brief discussion of the relationship between energy conservation and some of the more important personal and national objectives and priorities follows.

Energy and Economic Growth

If all countries are taken together a general correlation between rates of energy consumption and economic activity is observed. This correlation, however, is not apparent when one compares only the more highly developed industrialized countries. For example, in Sweden, a highly industrialized country with a climate and living standard much like Canada's, one-third less energy is used per person than in Canada. France, Germany, Finland, the United Kingdom, Denmark and Italy all use less than half the energy per person, and considerably less energy per dollar of output than Canada.

After all of the obvious factors, such as climate, geography and industrial structure have been accounted for, a difference remains between the rates of energy consumption in North America and elsewhere that is only explainable on the basis of lifestyles and relative efficiency of energy use. For example, cars are typically more fuel efficient in Sweden, houses are typically better insulated, and the Swedish pulp and paper industry is typically more energy efficient at the higher energy price levels now prevailing in both countries. It is clear that, in Canada, significant reductions in wasteful energy practices can be made without detriment to economic growth*.

Energy and Quality of Life

Quality of life is a personal perception based on individual preferences and means of satisfaction. There may be conflicts with particular energy conservation measures where preferences are for activities or possessions which involve the inefficient use of energy such as large cars for transporting one or two people or large individual family homes when multiple dwelling units would be more efficient. The moral suasion element of conservation strategies is aimed at guiding these preferences in a less energy consuming direction by pointing out the various costs involved, and alternatives available.

Energy and Employment

During this century, and particularly in the 1948-1973 period, energy was substituted for labour as the relative price of energy declined. Now through the impact of higher relative energy prices, one can reason that there is likely to be some shift back to labour, resulting in more employment opportunities.

In the case of specific conservation measures, despite some uncertainties, studies indicate that most will have a positive overall effect on employment, although specific workers and even specific regions may be adversely affected. Such problems should be met by mechanisms designed to compensate for inequities and to ease the transition to new economic pursuits.

---

* A recent study of the effect of lower energy growth rates in the United States concluded that if zero energy growth were attained by the year 2000, GNP would only be 4 per cent below the level attained if pre-1973 energy growth rates had been maintained to 2000.

Energy and Standard of Living

The proportion of income spent directly on energy decreases as income rises: low income families spend a disproportionately large share of their income for space and water heating, lighting, cooking and gasoline for automobiles. Consequently, conservation measures for improving the efficiency of direct energy usage by individuals will have a beneficial impact on the real incomes of poorer Canadians. However, an initial capital cost often accompanies the adoption of energy efficiency improvements (such as increased levels of insulation) and this may place a particular burden on poorer Canadians. Special approaches, such as direct grants or favourable loan terms are needed in some situations to enable all Canadians to take advantage of capital-intensive conservation opportunities.

It is sometimes argued that the use of higher prices to encourage conservation is a hardship to lower income groups. Appropriate energy pricing is, however, basic to the efficient use of energy throughout the economy and if the impact of higher energy prices on the poor is unacceptable, the problem should be tackled directly, as an element of overall income distribution policy. The use of mechanisms, such as the Ontario Property Tax Credit, will serve distributional objectives while at the same time allowing appropriate price signals to reach consumers and suppliers of energy.

Strategies for Energy Conservation

A range of actions may be included in a national program to reduce energy demands in Canada. They will have varying degrees of acceptability—on economic and social grounds—in the context of a given supply situation. The general strategies which are outlined below form the overall context for conservation programs which may be within the jurisdiction of the federal, provincial or municipal governments, depending on the specific policy area involved.

Changing Attitudes and Preferences by Improved Information

As Canadians become better informed about the national energy picture and the role energy plays in their lives, they will reassess their overall preference patterns and will tend to consume less energy than they would otherwise have done. It is therefore important to develop and widely distribute a comprehensive range of information on the emerging energy situation in Canada, stressing options and outlining the costs and benefits of each.

Pricing

To provide incentives for the efficient use of energy, the price of basic energy commodities should indicate the real costs of supplying additional quantities from domestic and foreign sources. Departure from this principle may be necessary in some cases, but the implications of such a departure should be set out clearly since, for example, subsidization of energy production, either directly or through taxation incentives, will encourage higher energy demand growth rates and possibly create serious long-term problems.

The federal government began basic energy pricing revisions by moving oil prices towards international levels and natural gas prices towards an energy equivalence with oil. This is a key element of the Government's national energy strategy. However, pricing policies should be directed not only at basic unit prices but also at rate structures*. These matters are currently being reviewed by several utilities.

Some observers claim that once energy prices fully reflect the current and future costs of supplying the various forms of energy from domestic and foreign sources, further promotion of conservation will be unnecessary. It is unlikely, however, given habit persistence, the lack of adequate consumer information and institutional barriers, that pricing actions alone will reduce energy demands to the extent or with the speed required to prevent undue economic and/or social dislocation over the next 10 to 15 years.

Adjustment of Institutional Factors

The existing market framework has developed as a response to past situations and problems: it contains biases against the efficient use of energy and also lacks elements—incentives, disincentives, regulations—that could promote more efficient energy use. Two types of adjustment measures may be distinguished and the majority of the specific sectoral conservation measures analyzed in Chapter 3 of this report fall into one of these categories:

- *Removal of biases that discourage efficient energy use.* An important example occurs when individuals or firms that construct buildings do not operate them. The operators, in turn, are often not the ultimate users, and consequently even at higher energy prices there are only weak incentives for the buildings to be heated efficiently. Measures to restore incentives include taxation and efficiency standards (e.g. in building codes).

- *Introduction of incentives, disincentives and regulations.* This type of adjustment actively introduces biases towards lower energy demands. Included in this category of measures are initiatives such as grants and loans for expenditures in energy use reduction, tax credits, energy taxes, and regulation of energy usage (e.g. sales-weighted fleet averages for automobiles).

Rationing

Rationing schemes pose extremely difficult problems because a completely equitable basis for rationing is virtually unattainable; prolonged rationing causes severe industrial disruptions, and involves high administrative costs. A prime objective of an energy conservation program is to *avoid* reaching a situation where rationing is required.

Format of the Report

In the following chapters there is a detailed discussion of how conservation measures could bring about energy savings in each of the four main end-use sectors: industry, transportation, residential and commercial. Conservation

---

* Declining rate structures, employed by most Canadian electrical and gas utilities, set lower charges for blocks of energy as more energy is used in a given time period.

programs now in effect or planned (both federal and provincial) are described. In addition, there is a review of other significant energy conservation measures that transcend the four sectors. There is also discussion of the need for research and a review of federal research programs.

The reader who wishes to obtain a comprehensive picture of the various conservation measures and how they can bring about energy savings will find these chapters rewarding. It is appreciated however that some readers may not have the time or desire to go into this level of detail and will wish to turn immediately to the results and conclusions. For this reason we provide in the next chapter a summary of the analysis and a list of the conclusions that can be drawn from it.

Chapter 2. SUMMARY OF ANALYSIS AND CONCLUSIONS

The 1976 *Energy Strategy* report postulated two scenarios, one of which assumed that the structure of domestic energy prices would adjust to international levels. This scenario predicted the average annual rate of growth of primary energy demand over the period 1976-1990 to be in the range of 3.7 to 4.3 per cent (depending on the rate of economic growth). No explicit action to encourage conservation was assumed other than the impact of energy price increases.

On the basis of this projection, and in support of the self-reliance objective of the National Energy Strategy, the Government of Canada adopted a number of specific energy targets, one of which was:

> "reducing the average rate of growth of energy use in Canada, over the next ten years to less than 3.5 per cent per year".

The energy consumption estimates of the present study are based on the same high price - low economic growth scenario, as that used in the *Energy Strategy* report and, in addition, include the estimated impact of certain specific conservation measures in the major energy end-use sectors. These measures give a full payback of any required investment in less than five years. Further they require only minimal changes in lifestyles and economic structure.

The results of this analysis indicate that the energy savings accruing from such conservation measures could give Canada an annual growth rate of secondary energy consumption in these sectors of 1.3 per cent over the period 1975-1990, and that, with some allowance for conservation measures in the energy industry itself, the rate of primary energy consumption growth could be about 2.0 per cent as compared with 3.7 per cent for the same basic scenario in the *Energy Strategy* report.

In absolute energy terms, the total difference between the *Energy Strategy* scenario and the energy conservation scenario in 1990 is approximately 2.8×10^{15} Btu or the equivalent of 482 million barrels of oil. If, in 1990, the mix of energy sources were the same as that which prevailed in 1975, the primary energy savings could amount to:

Petroleum	1.29 quads, equivalent to the annual output of five Syncrude-size oil sands plants, or about 600,000 barrels per day of crude oil
plus Natural Gas	0.51 quads, equivalent to about 20 per cent of total Canadian production in 1975
plus Electricity	0.79 quads, equivalent to the annual output of thirteen Pickering-sized nuclear plants

plus Coal .... 0.21 quads, equivalent to 8.5 million short tons of bituminous coal.

The energy conservation scenario is not a forecast of energy demand, since there may well be unforeseen economic, social and technological change during the time period, and the conservation savings in some consuming sectors cannot be quantified with any degree of accuracy. It is simply a picture of one possible future pattern of energy demand, based on an assessment of likely conservation measures within the context of certain assumed social and economic conditions.

The results of the analysis are depicted in the following tables and charts:

• *Table 1* provides a comparison between historical energy growth rates, rates projected by the 1976 *Energy Strategy* report and the rate suggested by the conservation scenario.

Table 1

Historical and Projected Energy Growth Rates
(Per cent per Year Averaged over Period Shown)

Source	*Primary Energy*	*Secondary Energy*[a]	*Remarks*
Actual			
1. 1945-1970	4.5		
2. 1962-1972	6.3	5.6	
3. 1974-1976	2.0		Too early to validly predict any trend but decrease from (2) certainly due partly to economic recession as well as higher energy prices and conservation.
Projected			
4. 1975-90 High price/high growth[b]	4.3	3.5	Down from (2) largely because of higher prices.
5. 1975-90 High price/low growth[b]	3.7	2.7	Down from (4) because of slower economic growth.
6. 1975-90 Target rate of growth[b]	3.5 max.		Down from (4) and (5) because of specific but unquantified conservation measures.
Conservation Scenario (1975-90)			
7. 1975-90 High price/low growth (with conservation measures described in this report)	2.0	1.3	Down from (5) because of greater emphasis on measures leading to efficiency of energy use.

[a]For projected growth rates, excludes all energy used by energy supply sector.
[b]*Energy Strategy* report.

• *Table 2* compares the *Energy Strategy* scenario with the conservation scenario in terms both of energy consumption in 1990 and average annual rate of change of consumption over the period 1975-1990. The figures are broken down under the four main end-use sectors. Further explanation of the table is given in Appendix A.

Table 2

Two Energy Demand Scenarios[a] for Canada to 1990

	Energy Consumption (10^{15} Btu)			*Average Annual Rates of Change (%)*		
		1990 Projected			*1975-90 Projected*	
Sector	*1975*[b]	*Energy Strategy (3.7%) Scenario*	*Energy Conservation (2.0%) Scenario*	*Historical*[c] *1962-72*	*Energy Strategy (3.7%) Scenario*	*Energy Conservation (2.0%) Scenario*
Residential	1.25	1.36	1.07	4.0	0.6	−1.0
Commercial	0.92	1.48	1.06	10.9	3.2	0.9
Transportation	1.54	2.60	1.88	5.4	3.6	1.3
Industrial	1.62	2.52	2.47	4.8	3.0	2.9
END-USE SECONDARY DEMAND[d]	5.33	7.96	6.48	5.6	2.7	1.3
Energy supply[e]	1.32	2.71	1.93		4.9	2.6
NET PRIMARY DEMAND[f]	6.65	10.67	8.41		3.2	1.6
Electricity value adjustment[g]	1.38	2.80	2.26			
GROSS PRIMARY DEMAND[h]	7.87	13.47	10.67	6.3	3.7	2.0

NOTES:

[a]These two demand scenarios are both based on one of the sets of demographic and economic assumptions used in the *Energy Strategy* report–the so-called "high price-low growth" scenario. The conservation scenario further allows for the effect of specific conservation measures, as outlined in the text.

[b]Estimates from the EMR energy demand model.

[c]Figures based on Statistics Canada Catalogue 57-207.

[d]Represents the energy demand by the four major energy-use sectors. Note that this differs from secondary energy as discussed in Statistics Canada publications in that it excludes *all* energy used by the energy supply sector.

[e]Not as defined by Statistics Canada (see Chapter 3). Here includes direct consumption and losses by the energy supply industries, conversion losses from thermal electricity generation, transmission losses, non-energy products and conversion losses.

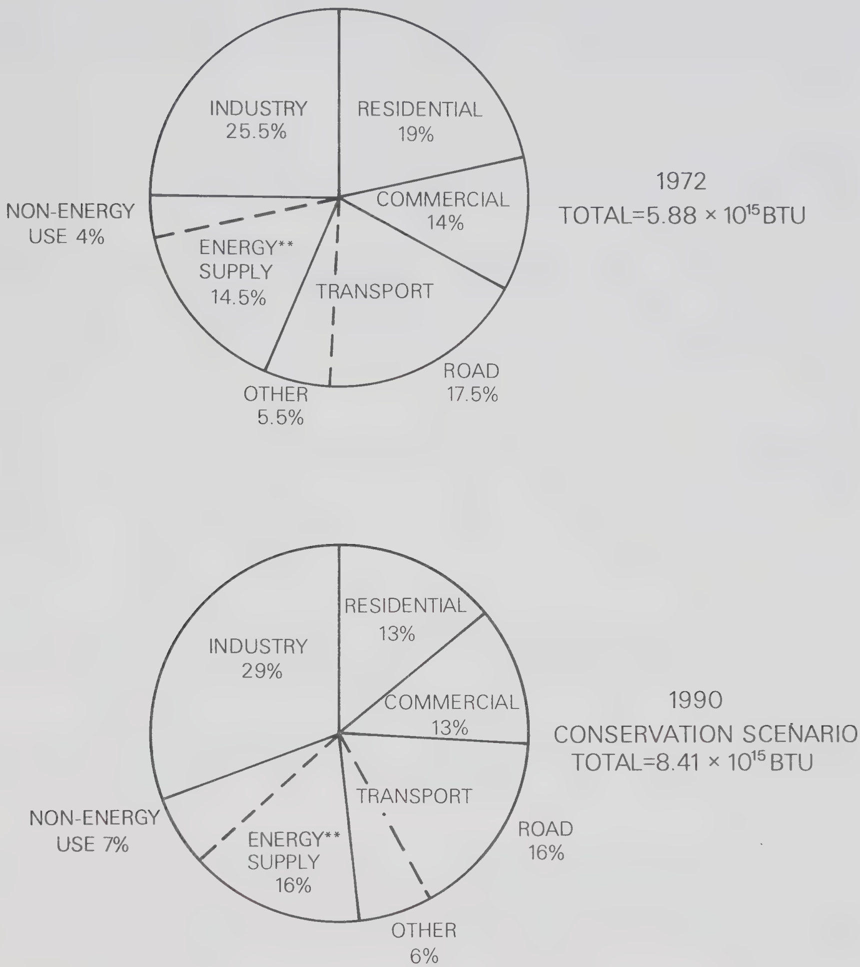
[f]Represents the primary energy demand, with hydro and nuclear electricity valued at 3412 Btu per kWh.

[g]Adjustment to present hydro and nuclear electricity at 10,000 Btu per kWh.

[h]Represents the primary energy demand with all electricity valued at approximately the fossil fuel equivalent.

• *Figure 1* shows, in terms of percentages, the sectoral breakdown of the total primary energy consumption in Canada for 1972 and for the 1990 conservation scenario.

Figure 1. Distribution of Net* Primary Energy Demand, 1972 and 1990



*Excludes adjustment to convert hydro and nuclear electricity to approximate fossil fuel equivalent.

**Includes conversion losses.

Conclusions

1. The energy conservation target which was proposed in the 1976 *Energy Strategy* report—a primary energy demand growth rate of less than 3.5 per cent per year over the period to 1985—is clearly attainable.

2. Given the social and economic conditions assumed in this report (which include an average annual population growth rate of 1.2 per cent and an average annual GNP growth rate of 4.2 per cent), the attainment of a national primary energy growth rate of 2 per cent averaged over the period 1975-1990 appears feasible.

3. The conservation programs that are either in operation or in the process of implementation should be adequate to achieve this growth rate, provided that the assumptions referred to above reflect the future socio-economic situation.

4. The reduction in the growth rate of energy demand to 2.0 per cent would significantly help to balance domestic energy supply and demand. Even if the socio-economic assumptions of the conservation scenario turn out to be incorrect, the reduction in energy demand growth due to the conservation measures analyzed will still facilitate the achievement of national objectives.

5. The personal automobile and space heating have been the two specific areas of energy consumption where it has been felt that there are significant opportunities for conservation over the period under consideration (1975-1990). For this reason, these two areas have been given initial major emphasis by the federal goverment in the development of its energy conservation program.

6. Industrial energy use offers opportunities for conservation through measures that are within the bounds of normal commercial practice. Many firms in all industries are beginning to develop an awareness of these possibilities.

7. Although not quantified in this report, use of what are today thermal and material wastes could make a significant contribution to a reduction in energy demand.

8. In the longer term (i.e. beyond 1990) there appears to be potential for further lowering of the energy demand growth rate through a greater emphasis on energy conservation in production processes, human settlements and transportation systems, and through a shift towards less energy-intensive lifestyles.

9. Because energy consumption is a component of practically every human activity, research into energy conservation involves many disciplines in both technological and social fields. Three broad areas of research are called for to provide the knowledge and skills needed in Canada's energy future:

- *research into new technology and the redesign of present products and processes* with the aim of conserving energy and making better use of it.

- *research into the reorganization of human activities* aimed at bringing about a coordination of such factors as town planning, transport, recreation, building design, working hours, etc., so that less energy is used.

- *research into lifestyles and social values.* This could involve consideration of how to bring about a shift away from the high energy consuming activities that characterize life today—both in earning a living and in recreation.

Chapter 3. ENERGY CONSERVATION PROGRAMS AND THE OPPORTUNITIES FOR ENERGY SAVINGS

Introduction

Canadian secondary energy demand* grew at an average annual rate of 4.5 per cent per year between 1945 and 1970, and at 5.6 per cent per year between 1962 and 1972. In 1972, total secondary energy consumption in Canada stood at 5.5 quadrillion Btu (Table 3). Although figures for more recent years are available, data are presented for 1972 because it marks the end of an era of relatively stable energy prices; it is also used as the base year for the energy demand projections.

Table 3 shows that energy growth rates vary markedly from sector to sector. The four major energy end-use sectors, using the Statistics Canada classification, are industrial, transportation, residential and commercial, each of which is discussed in some detail in this study. The energy supply industries constitute another major energy end-use sector, but since their activities depend to a large extent on the level and mix of demand in the first four sectors, discussion of their energy conservation potential is more difficult; it is further hampered by a lack of consistent data. Agriculture is an important but not a major energy end-use sector, currently using directly less than 3 per cent of total Canadian end-use energy; again discussion of energy conservation prospects is hampered by a lack of data.

Sole reliance on the major end-use classification can overlook some areas of energy use where there are substantial energy conservation opportunities. Important examples include urban design, which is related to all of the major sectors, and is fundamental to a discussion of energy conservation potential in urban transportation and district heating systems; and combined production of heat and electricity (co-generation), which has a significant potential to improve efficiency of energy usage in the industrial and energy supply sectors, and through district heating, in the residential and commercial sectors. Also the broad sectoral classification fails to bring into perspective the significant savings potential from better matching of energy form to type of end use. For these reasons, the analysis of energy conservation prospects and policies discussed here includes both sectoral and non-sectoral approaches.

The conservation measures outlined in this report are by no means complete, but rather represent a collection of the most obvious, acceptable and readily applied techniques to improve the efficiency of energy usage. They are considered to be technically feasible and, where direct economic evaluation can be made, give a full payback of capital expenditures (where these are required)

---

* Here includes energy used by the energy supply industries and non-energy products, but excludes conversion losses. This is the case for all historical total secondary demand figures quoted from Statistics Canada in this chapter.

through direct energy savings within five years. Due to data and quantification problems in some instances, only certain sectoral measures have as yet been quantified for the purposes of making energy demand growth rate projections over the 1975-1990 period.

Table 3

Canadian Secondary Energy Consumption by Sector, 1972

Sector		Energy Use (10^{12} Btu)		Percentage of Total		Approx. Per Year Rate of Increase 1962-1972
Transportation		1,339.36		24.33		5.4
	Road	*1,023.14*	*18.59*		*5.8*	
	Rail	*93.69*	*1.70*		*2.7*	
	Air	*105.35*	*1.91*		*8.0*	
	Marine	*117.18*	*2.13*		*2.7*	
Domestic and farm[a]		1,131.59		20.56		4.0
Commercial		828.74		15.06		10.9
Industrial		1,493.74		27.14		4.9
Energy supply industries[b]		589.31		10.71		8.6
Losses, non-energy use, etc.		121.34		2.20		–
Total		5,504.08		100.0		5.6

SOURCE: Statistics Canada, *Detailed Energy Supply and Demand in Canada*, 1958-1969 and 1972. Breakdown by fuel type is also available from this publication.

[a]Residential is the term generally used for the domestic sector which accounts for over 97 per cent of energy usage in the domestic and farm sector.

[b]As defined by Statistics Canada: includes own use of energy by the supply industries and losses during electrical and gas transmission, but not conversion losses.

In order to produce sectoral and total estimates of future energy consumption based on the implementation of these measures, a baseline projection of energy demand in 1990 was developed. The energy savings estimated to result from expected price changes and specific conservation programs were subtracted from this baseline. The baseline projection was produced from the energy demand model used in the *Energy Strategy* report*, but with an assumption of 1972 prices**. In this way it was ensured that there was no double counting of the frequently inseparable effects of higher energy prices and conservation. Thus, in the conservation scenario, major socio-economic variables such as population, economic activity and energy prices closely correspond to the high price — low growth scenario of the *Energy Strategy* report***.

* Fully discussed in *Energy Demand Projections—A Total Energy Approach*, Dept. Energy, Mines and Resources, Ottawa, Canada, 1977, Report ER 77-4.

**None of the actual scenarios developed for the *Energy Strategy* report could be used as a baseline for these calculations since some modification of demand from historical rates is already implicit in the pricing assumptions made.

*** Economic growth averaging 5.4 per cent per year to 1980, 3.6 per cent thereafter; population rising to 27.5 million in 1990; crude oil prices rising to about $13 (1975) per barrel landed at Montreal by the late 1970's. For full details, see *Energy Strategy* report, *op. cit.*, p. 49.

In addition to analysis of the impact of specific conservation measures, Canadian program initiatives to date (both federal and provincial) are outlined for each major end-use sector, together with other possible actions that could further reduce the rate of growth of energy consumption.

Energy Conservation in Buildings

Buildings are the main component of two major end-use sectors—residential and commercial*. The largest proportion of energy used in these sectors is for space heating and cooling, although water heating, lighting, appliances and business machines also consume significant amounts. In developing policy approaches, it is necessary to distinguish between existing and new buildings and their components, and between owner-occupied and rented buildings.

Background

Residential

The residential sector currently accounts for approximately 20 per cent of secondary energy consumption, although this proportion has been declining. Energy consumption in residences over the period 1962-1972 grew at an average annual rate of 4.0 per cent, somewhat less than the overall average growth rate in secondary energy use of 5.6 per cent**. Table 4 illustrates the trend.

Commercial

Energy consumption statistics for the commercial sector, although not well detailed, reflect energy consumed in schools, wholesale and retail stores, offices, government activities, hospitals, hotels and motels, and other commercial activities. Because all gas and electricity charged at commercial rates is incorporated into the commercial energy consumption statistics, some consumption by light industry and apartments is included. It is estimated, however, that at least 90 per cent of commercial energy consumption is accounted for by commercial buildings.

In 1972, approximately 15 per cent of total secondary energy consumed in Canada was used in the commercial sector. The average annual growth rate of 10.9 per cent between 1962 and 1972 was well above the total Canadian secondary energy growth rate of 5.6 per cent. This resulted partially from the rapid increase in the size of the commercial sector, as well as from the increased demand for energy in new buildings: air conditioning was increasingly installed, higher lighting levels were recommended, and the use of electrical business machines increased significantly.

---

* Energy use in industrial buildings is covered in the industrial sector section; most of the policy approaches outlined here for the residential and commercial buildings would also apply to industrial buildings.

** Statistics Canada figures in *Detailed Energy Supply and Demand in Canada* combine some farm consumption in the residential sector; however, farm consumption is small (less than 3 per cent of national consumption). In addition, some residential consumption is incorporated into the commercial classification (in particular that consumption in large residential complexes which is charged at commercial rates). Although the residential consumption in the commercial sector may amount to over 2 per cent of national consumption, no detailed breakdown exists.

Table 4

Secondary Energy Consumption in Residences, 1962-1972
(10^{12} Btu)

Year	Total Residential Consumption	Total Residential Per cent of Total Secondary Consumption	Total Residential Per cent Average Annual Growth Rate from 1962	Space Heating[a] Consumption	Space Heating[a] Per cent of Total Secondary Consumption	Water Heating[a] Consumption	Water Heating[a] Per cent of Total Secondary Consumption
1962	762.9	24.0	–	534.1	16.8	137.3	4.3
1965	866.2	22.5	4.3	600.3	15.8	155.9	4.1
1970	1,036.2	20.5	3.9	725.3	14.4	186.5	3.7
1972	1,131.6	20.6	4.0	792.1	14.4	203.7	3.7

SOURCE: Statistics Canada, *Detailed Energy Supply and Demand in Canada*, 1958-1969, 1970 and 1972. Catalogue 57-505.

[a]Space heating and water heating are assumed to comprise 70 per cent and 18 per cent respectively of total residential energy consumption. This represents most of the energy used as heat in this sector and all of it is consumed at "low" temperatures, i.e. temperatures below 100°C. See V.R. Puttagunta, *Temperature Distribution of The Energy Consumed as Heat in Canada*, Atomic Energy of Canada Ltd., Pub. No. AECL-5235, Oct. 1975.

Table 5

Secondary Energy Consumption in Commercial Establishments, 1962-1972

Year	Annual Consumption[a] (10^{12} Btu)	Per cent of Total Secondary Consumption	Per cent Average Annual Increase from 1962
1962	295.0	9.3	–
1965	425.8	11.1	13.0
1970	700.8	13.9	11.4
1971	734.5	14.1	10.7
1972	828.7	15.1	10.9

SOURCE: Statistics Canada, *Detailed Energy Supply and Demand in Canada*, 1958-1969, 1970, 1971 and 1972, Catalogue 57-505.

[a]About 85 per cent of commercial energy is consumed as heat, all of it at temperatures below 100°C. See V.R. Puttagunta, *op. cit.*

Federal Actions to Date

• An information and awareness program on the possibilities for householders to use energy more efficiently, for example by reinsulation of homes, regular maintenance of furnaces and thermostat setbacks has been vigorously pursued over the past two years by means of books and radio, TV and newspaper advertisements. Publications from the Office of Energy Conservation dealing

with energy conservation in the home include: *100 Ways to Save Energy and Money In the Home, Keeping The Heat In,* and *The Billpayer's Guide to Furnace Servicing.*

Two important demonstration projects for buildings have been undertaken in co-operation with the governments of Prince Edward Island and Newfoundland, where a residential energy audit program—"Enersave"—was run for possible application in other regions of Canada. The Enersave program entails the completion of a questionnaire on the thermal characteristics of a residence—area, number of occupants, existing insulation, etc.—which are then computer-analyzed. From this computer analysis the homeowner receives recommendations on economic actions to improve thermal efficiency. Enersave is now being run in conjunction with the Canadian Home Insulation Program (see below) in all participating provinces.

• New building codes throughout Canada are necessary to ensure that buildings are constructed to standards that reflect current and expected energy costs. The development of a draft "Canadian Code for Energy Conservation in New Buildings" was completed by a standing committee of The Associate Committee on the National Building Code in June 1977. This code contains thermal efficiency standards based on economic and technical criteria developed by the National Research Council (NRC) for a number of climatic regions defined in terms of degree-days*. The code is being applied to Federal housing programs (for example those operating under the National Housing Act). Jurisdiction over building codes rests primarily with the provinces and most have agreed to adopt energy standards at least as high as those contained in the new draft code by early 1978. The success of this measure will require the availability of building inspectors responsible for assessing the energy efficiency of buildings.

• The Canadian Home Insulation Program recently announced by the federal government offers direct grants of two thirds of the cost of home insulation materials (up to $350), to encourage the reinsulation of existing residential units. In Prince Edward Island and Nova Scotia, a different reinsulation program has been in effect since 1 January 1977, and response by the public has been overwhelming.

• Increased furnace operating efficiencies can make a substantial reduction in energy demands for space heating: average seasonal efficiencies have been estimated at 60 per cent in the existing housing stock and 70 per cent in new housing. Government programs are being developed to encourage the enactment of minimum efficiency standards for new furnaces and improved servicing of existing ones. Plans for the improved training and certification of furnace servicemen are currently under discussion with the provinces and the industry.

---

* The degree-day indicates the amount of heating required for small buildings in a given area. The value for degree-days is calculated by summing the difference between 18°C and the mean daily outside temperature over all days during which the temperature is below 18°C. Typical degree-day values are as follows: St. John's, 4997; Halifax, 4072; Montreal, 4539; Toronto, 3775; Winnipeg, 5915; Edmonton, 5687; Vancouver, 3046.

• The operation of buildings accounts for 58 per cent of the total energy consumed by the federal government. Through its Internal Energy Conservation Program (discussed more fully in Chapter 4) the federal government is significantly improving its energy management (in all its energy consumption and not just buildings) and thereby saving energy and dollars, and setting an example for others to follow.

• An appliance energy labelling program, supported by a comprehensive publicity program is being developed to encourage appliance purchase decisions that take into account operating as well as purchase (capital) costs.*

• Excise and sales taxes on energy conserving equipment for buildings have been removed: this includes insulation materials and heat pumps.

• Federal support for research and development and demonstration by private, university and government agency research groups is being increased in the area of energy conservation in buildings.

Provincial Actions to Date

At this time it is anticipated that most provinces and the territories will have adopted the proposed national insulation standards into their building codes by early 1978.

Some provinces have announced loan programs for reinsulation of dwellings; others are in the process of developing such programs. By the end of 1977, it is expected that the sales tax on insulation materials will be removed in most provinces. In addition, many provinces intend to eliminate the bulk metering of electricity (electricity charged to a group of housing units, rather than to individual units) in new multi-family dwellings.

Further Possible Conservation Measures

• The absence of incentives to improve energy efficiency in rented buildings is particularly serious. Energy costs may be borne directly by tenants, or may be passed on to tenants as part of their rent, so that landlords have little incentive to improve the thermal efficiency of their buildings. Even where landlords do pay the energy costs, the costs are fully deductible from their income as a non-taxable expense.

Incentives could be created, in this latter case, by the partial disallowance of these costs for tax purposes. Revision of certain sections of provincial Landlord and Tenants Acts could also help restore incentives by permitting a reasonable return on investments that are designed to improve the thermal efficiencies of buildings.

• Legislated minimum efficiency standards for appliances, particularly those usually supplied by the builder or landlord (e.g. water heaters) warrant serious consideration. In cases where the purchaser does not bear the costs of operating

* All decisions on capital outlays involving energy use (for example, buildings, industrial equipment, appliances, automobiles) should take into account full life-cycle costing: that is, accounting for both capital and lifetime operating costs, using an appropriate discount rate.

the appliance and hence will tend to minimize purchase costs rather than life-cycle costs, labelling alone is likely to be ineffective.

- Energy reductions could be achieved by a wider use of more efficient light sources (such as fluorescent lights) and by a revision of lighting standards, many of which are unreasonably high. Research and technical evaluation is being supported at the federal level but lighting guidelines and codes are almost completely under provincial jurisdiction. The federal government is setting an example by reducing lighting levels in its own buildings. In the Department of National Defence alone 30,000 fluorescent tubes have been permanently removed.

- Mandatory thermal efficiency standards for existing buildings are difficult to enforce. However, such standards would dramatically reduce energy consumption, and would have some acceptance if carefully based on acceptable economic criteria combined with retrofitting incentives. This measure would help considerably in overcoming the weak incentives to retrofitting rented buildings.

- District heating involves the provision of space heating and cooling from a central source to the surrounding industrial, commercial or residential communities. The heat source can be either waste heat from a conventional or nuclear power plant or heat generated in special boilers which can be fuelled by oil, gas, coal or waste products such as garbage.

In several large Canadian cities, district heating schemes have been in existence for many years, but they are generally steam systems for commercial use only, with heat being supplied to a few large buildings in the downtown core. Several provinces are interested in developing modern, hot water district heating systems for new town sites. Although a major impact from district heating will not likely be felt for another 15 to 20 years because of the long lead times required to construct the plants and distribution systems, district heating could further reduce residential consumption of fossil fuels, both by providing more efficient central heating units than domestic furnaces and by utilizing waste heat. To encourage wider adoption of district heating in Canada, public funding may be necessary to stimulate the design and development of viable district heating schemes*.

- Solar space heating. It is widely accepted that by the year 2000 a considerable contribution to Canadian space heating requirements can be made by solar energy. Public and private funds are needed to develop commercially viable space heating systems for specific applications in all energy use sectors. Current barriers to the implementation of solar heating must be identified and appropriate incentives must be introduced to encourage the use of alternate energy forms in all building types.

There is also significant potential for the passive use of solar energy, i.e., the design and alignment of buildings to reduce the total heating load. Some aspects of this potential have been accounted for in the proposed new energy conservation code for new buildings discussed in a previous section (Federal Actions to Date).

---

* A fuller discussion of the potential for district heating in Canada is contained in Chapter 4.

Achievement of the potential of solar energy in space heating, both active and passive, will require a mechanism to ensure that buildings relying on this energy source are not subsequently shaded by new developments ("right to light"). This may require innovative legislation.

Analysis of Probable Energy Savings to 1990

Residential

To analyze the probable energy savings from conservation measures in the residential sector, the sector was divided into two components: space heating, which makes up 70 per cent of the total, and all other residential consumption.

Three major areas were identified as having significant potential for conservation in space heating at 1976 energy prices: reinsulation of existing homes, adoption of improved energy standards for new homes, and improved heating systems.

A study funded jointly by the Central Mortgage and Housing Corporation (CMHC) and the Office of Energy Conservation showed that a 37 per cent saving in the space heating requirements of existing residences can be achieved by reinsulating residential units to levels of insulation which give a payback on insulation investment within 5 years at current energy prices. The present analysis assumes that by 1985 this average level of savings would be realized in 70 per cent of the 1975 stock of dwellings (i.e. approximately 5 million of the existing 7 million units would be reinsulated). This degree of retrofit would likely be achieved through full provincial participation in the recently announced Canadian Home Insulation Program. The cost to the federal government, mainly in the form of grants to householders, could be up to $1.4 billion (1976 dollars) out of a total reinsulation cost of approximately $4.4 billion. The saving from the baseline* would be 218×10^{12} Btu or 38 million barrels of oil equivalent per year in secondary energy, by 1990.

Adoption throughout Canada of energy efficiency standards in building codes would reduce space heating consumption by 38 per cent in buildings built after 1975, compared with a baseline developed by assuming continuation of 1972 prices and 1975 CMHC standards**. This would produce a saving of 100×10^{12} Btu in 1990, or about 17 million barrels of oil equivalent.

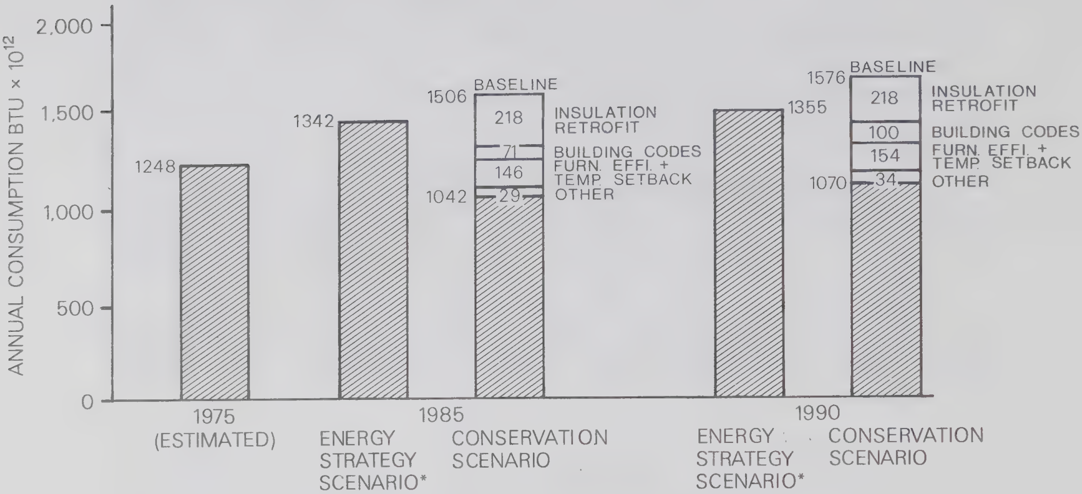
Improved heating system efficiency and temperature setback can also significantly reduce energy demand growth rates for space heating in the residential sector. It is estimated that a combination of increased efficiencies in new heating systems, improved maintenance and retrofitting of existing furnaces and temperature set back to 18°C at night and 21°C during the day, would result in a further saving of 154×10^{12} Btu or 26 million barrels of oil equivalent per year, by 1990.

---

* For an explanation of the baseline, see page 15.

** This analysis was based on the Housing and Urban Development Association of Canada (HUDAC) building guidelines. The draft national energy code contains more stringent standards than the current HUDAC guidelines and hence full implementation of this draft code would lead to greater energy savings.

Figure 2. Possible Energy Savings in Residential Sector, 1975-1990.



* *Energy Strategy* report, high price — low economic growth scenario. Both this and the conservation scenario are based on the same socio-economic assumptions. This scenario is different from the baseline demand from which the conservation savings are subtracted, because it includes demand reductions occurring in response to higher energy prices.

The non-space heating portion of residential consumption was assumed to moderate in response to increased energy prices in the same way as the sector as a whole behaves in the EMR energy demand model.

The total estimated annual saving from the baseline in the residential sector in 1990 would amount to 506×10^{12} Btu per year, or 88 million barrels of oil equivalent (secondary energy) per year. Figure 2 shows the savings expected to result from the various measures, and the consequent sectoral demand under the conservation scenario for 1985 and 1990. Sectoral demand is also compared with the low growth - high price scenario of the *Energy Strategy* report* (see also Appendix A).

In addition to the adoption of a national insulation retrofit program and building codes by all provinces, attainment of these savings will require:

- increased information on and regulation of furnace maintenance, including much improved training for servicemen;
- increased information on the advantages of reinsulation and temperature setback; and
- the availability of building inspectors responsible for assessing energy efficiency.

All of these measures are currently being acted upon.

---

* *Energy Strategy* report, *op. cit.*, low growth - high price scenario. This comparison is more fully discussed in Appendix A.

Commercial

Although a serious lack of data for the commercial sector prevents a rigorous analysis, estimates of potential energy savings in space heating and cooling of commercial buildings were attempted on the basis of demonstrated results from specific public and private projects. The residual energy usage in this sector was assumed to show the same response to price as the whole sector in the EMR energy demand model. Together these give a total estimated saving from the baseline of about 600×10^{12} Btu or about 100 million barrels of oil equivalent for 1990. In addition to the adoption of building codes, policies would be required to encourage the use of improved techniques in building operation and maintenance. It must be recognized that this saving is a preliminary estimate based on assumptions.

Energy Conservation in the Transportation Sector

Background

Canada is a vast country, with long and complicated transportation networks connecting metropolitan areas and small regional communities. Not surprisingly, transportation accounts for almost one quarter of total secondary energy consumption. The rate of consumption grew at 5.4 per cent annually over the period 1962-1972 (see Table 6), and was only marginally below the 5.6 per cent growth of total Canadian secondary energy consumption over the same period.

The rates of increase in energy use shown in Table 6 emphasize the importance of conservation in the road and air modes if any appreciable demand reduction is to be realized by 1990. Although air travel consumed only 1.9 per cent of Canada's energy in 1972, its high growth rate before 1973 would have resulted in a doubling of consumption in only nine years.

Table 6

Secondary Energy Consumption in Transportation, 1972

	Energy Use (10^{12} Btu)	*Percentage of Total Canadian Energy Consumption*	*Annual Percentage Increase, 1962-72*
Road	1,023.14	18.59	5.8
Rail	93.69	1.70	2.7
Air	105.35	1.91	8.0
Marine	117.18	2.13	2.7
Total	1,339.36	24.33	5.4

SOURCE: Statistics Canada, *Detailed Energy Supply and Demand in Canada*, 1958-69 and 1972.

Unlike other major energy consuming sectors of the economy, transportation is almost entirely dependent on petroleum, and accounts for over 42 per cent of national consumption. Table 7 compares 1972 energy consumption by each transportation mode. The largest consumers are automobiles (53.4 per cent of total transport use) followed by trucks (22.0 per cent).

The energy intensity* of the various modes of transportation is outlined in Table 8, which indicates that the three largest consumers of energy (automobiles, air transport and trucks) are also the most energy intensive. That is, they use more energy per unit of transport work provided. The table shows average figures based on aggregate fuel consumption data and estimated average mode productivity. Fuel consumption varies substantially under real operating conditions (such as distance, load factor, speed, temperature, number of stops, etc.), which can change the relative order of energy intensity. For example, the system-wide energy intensity for passenger rail, 4,370 Btu/passenger mile, reflects the under-utilization of present-day rail services. Individual trains travelling on the Windsor-Quebec City corridor show much lower energy intensity (about 1,100 to 2,200 Btu/passenger mile).

Table 7

Secondary Energy Consumption by Mode of Transportation, 1972
(Per cent of total transportation energy)

Automobile	Intercity	19.7		
	Urban	33.7		
			Sub-total	53.4
Bus	Intercity	0.3		
	Urban	0.5		
			Sub-total	0.8
Rail	Passenger	1.0		
	Freight	6.0		
			Sub-total	7.0
Truck	Intercity	8.4		
	Urban	13.6		
			Sub-total	22.0
Air				7.9
Marine				8.8
Total				100.0

SOURCE: Office of Energy Conservation; a synthesis from diverse published and unpublished sources.

* Energy intensity for the transportation sector is defined as the direct energy used as motive fuel per unit of transportation work, expressed in Btu per passenger-mile, or, for freight transport, Btu per ton-mile.

Table 8

Energy Intensity of Transportation Modes
(Btu of motive fuel per passenger-mile or ton-mile)

Passenger Traffic		*Freight Traffic*	
Intercity:		*Intercity:*	
Auto	3,280	Truck	2,500
Bus	830-1,250	Rail	560
Rail	1,100-7,200	Air	41,200
Air	3,400-8,000	Water	540
		Gas Pipeline	1,800
		Oil Pipeline	450
Urban:		*Urban:*	
Auto	7,820	Truck	7,000
Bus	1,650		

NOTE: Where no range is shown, the figures are averages.
SOURCE: Office of Energy Conservation; a synthesis from diverse published and unpublished sources.

Federal Actions to Date

• Fuel efficiency standards (sales-weighted fleet averages) have been announced for the range of automobiles marketed by each manufacturer and importer of automobiles in Canada. These standards are set at a minimum fleet average of 24 miles per gallon (mpg) for 1980, and 33 mpg for 1985,* and will make a major contribution to reduced energy consumption over the next 5-15 years.

• There is currently an excise tax on heavy cars sold in Canada. This tax is now under review, and consideration is being given to changing the basis of the tax from weight alone to a base which will better reflect fuel economy. Excise taxes of this type are complementary to the sales-weighted fleet average standards discussed above as they directly influence consumer purchase decisions towards more efficient automobiles and thereby assist the manufacturer in complying with the standards.

• A gasoline excise tax of 10¢ per gallon was imposed in 1975—as both a conservation measure and as a means of assisting the financing of compensation payments for oil imported into Eastern Canada.

• The federal budget of May 1976 announced a special excise tax of $100 on all new automobile air conditioners.

• In co-operation with motor vehicle manufacturers and importers, a voluntary automobile fuel economy labelling program was introduced during 1976. Dealer response to this program, however, has been poor.

• Information on automobile purchasing, fuel economy and maintenance has been developed in a series of pamphlets and media advertisements, that have

* 38 km per gallon and 53 km per gallon respectively.

been made available to the Canadian public. *The Car Mileage Book* published by the Office of Energy Conservation informs consumers on how to buy, drive, and maintain automobiles in order to reduce their gasoline consumption.

• Support for research and development in the transportation field, and also for demonstration projects, for example, car pooling, is increasing.

• The federal government has taken steps to reduce the energy used by its own vehicles, by placing a 55 mph speed limit on government vehicles, and introducing new purchasing guidelines stipulating smaller cars. The government internal program is more fully discussed in Chapter 4.

Provincial Actions to Date

Provincial governments have begun to introduce a number of measures that will encourage improved energy efficiency in the transportation sector. Automobile license fees in all provinces and the Yukon Territory are currently somewhat progressive with respect to automobile size (weight or wheel base) or engine size, and several provinces are planning to raise these fees in such a way as to further increase the relative cost of licensing larger cars. Most provinces have reduced or have planned to reduce speed limits by the fall of 1977 to 100 kilometres per hour (62 mph) on 4-lane highways and 90 kph (56 mph) on 2-lane roads. Increased support for public transit services is also being provided.

Further Possible Conservation Measures

• Changes to insurance legislation could encourage the wider use of pooling arrangements and achieve higher vehicle load factors. Private automobile insurance seldom permits payment for transportation services to the vehicle owner.

• A review and revision of trucking regulations at the local, provincial and federal levels could greatly improve the energy efficiency of road freight operations. Such legislation often hinders the attainment of high load factors by, for example, restricting the number of firms that can utilize a single truck-trip, or restricting back-hauling.

• A review and revision of air schedules to remove certain unnecessary restrictions could further encourage the recent improvements in load factors. In general, this means moving towards more flexible schedules, while still retaining key flights on a firm schedule basis.

• Further assessment of government subsidization of the various transportation modes with the elimination of any bias favouring energy-inefficient modes is required. Consideration may be given to increasing the relative subsidies to the most energy-efficient modes (bus and rail for passengers; rail, pipeline and ship for freight). Assuming similar load factors, this would tend to increase the overall energy efficiency of the transportation system.

• Urban traffic restraint measures can encourage the switch to public transit from automobiles. The measures could include banning private automobiles in certain areas at certain times of the day, the dedication of certain traffic lanes

to buses and multi-occupant vehicles and the restriction of available parking spaces.

• Significant energy savings could be achieved through the increased use of diesel engines. The increased capital cost of diesel units can be offset by their improved fuel economy, longer life and reduced maintenance. Tax incentives could be designed to increase market penetration of diesels in medium duty trucks.

Analysis of Probable Energy Savings to 1990

The baseline energy consumption estimates for passenger automobiles, trucks and air fuels on which the analysis of conservation savings were based are similar to those produced by the baseline projection previously described (page 15) but were modified by more recent information. In the baseline estimate it is assumed that:

(1) the average fuel economy and annual mileage per auto would not change from 1975 levels;

(2) passenger automobiles consumed 70 per cent of motor gasoline production in 1975;

(3) auto registrations would increase annually by 4.9 per cent to 1980, by 3.7 per cent between 1980 and 1985 and by 3.5 per cent between 1985 and 1990;

(4) air fuel consumption, truck and bus population, and personal-use light duty trucks and vans would increase at about the same rate as real GNP.

The conservation scenario assumes the adoption of a number of specific policy measures in certain key areas of transportation. These measures were chosen from a range of technically feasible options on the basis of reasonability and acceptability for implementation by 1990. The specific measures are:

(1) Canada will adopt (as already announced) fuel economy standards identical to the sales-weighted fleet averages legislated in the United States. This measure would reduce automotive fuel consumption in 1990 by 40 per cent from the baseline—a saving of 113 million barrels of gasoline in that year.

(2) A series of measures will be implemented to influence the type and amount of transportation in urban areas, with the result by 1990 that:

- most work trips into the core area would be made by public transit;
- work trips to other locations would involve average automobile occupancy rates of two or more;
- trips for non-work purposes would not increase significantly; and
- 20 per cent of all urban travel would be on transit facilities.

The sort of measures required to achieve this would include:

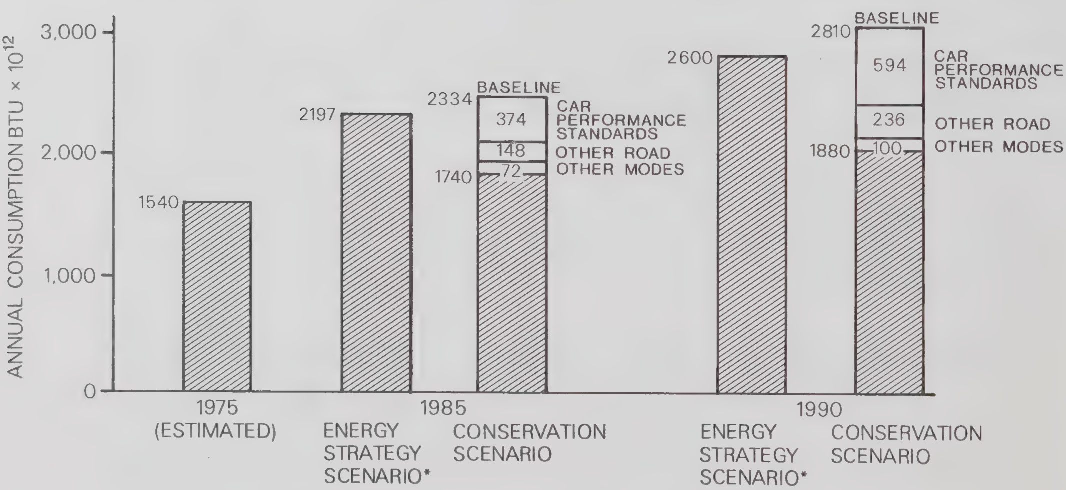
- an expansion of transit services;
- a slowdown in metropolitan road construction;
- the establishment of priorities for multi-occupant vehicles on main arteries and for parking;
- increased gasoline taxes and motor vehicle registration fees for heavier cars;
- a reduction in employment-related parking spaces; and
- an increase in the number of vehicle pools.

These measures could contribute savings of about 13 million barrels of gasoline per year by 1990.

(3) Fuel consumption would be reduced in air transport by about 20 per cent in 1990 by continuing the shift toward single-class seating, by ensuring increased load factors and by expected technical improvements in the energy efficiency of aircraft.

(4) Truck and bus fuel consumption would be reduced by 18 per cent from the baseline by 1990, mainly through increased use of improved diesel engines and minor low-cost technical improvements to the existing fleet.

Figure 3. Possible Energy Savings in the Transportation Sector, 1975-1990.



* *Energy Strategy* report, high price — low economic growth scenario. Both this and the conservation scenario are based on the same socio-economic assumptions. This scenario is different from the baseline demand from which the conservation savings are subtracted, because it includes demand reductions occurring in response to higher energy prices.

No modal shifts are assumed for intercity travel. Energy consumption for rail and marine transportation was assumed to change in response to increased prices, but no specific conservation measures were assumed.

For the transportation sector as a whole, a saving of 930×10^{12} Btu or 178 million barrels of oil equivalent per year is projected by 1990. Figure 3 shows the savings resulting from the various conservation measures, and the consequent sectoral demand under the conservation scenario for 1985 and 1990. Sectoral demand is also compared with that for the low economic growth - high price scenario in the *Energy Strategy* report (see also Appendix A).

Energy Conservation in the Industrial Sector

Background

The industrial sector includes primary and secondary industry, the major divisions being forestry, fishing and trapping, mining, manufacturing and construction.

According to Statistics Canada data, the sector accounted for 27 per cent of the total secondary energy consumption in Canada in 1972. Directly and indirectly, it used 40 per cent of the total, with most of the indirect consumption in the transportation of industrial supplies and products. In energy units, direct consumption was 1494×10^{12} Btu in 1972, and it increased over the period 1962-1972 at an average annual rate of 4.9 per cent*.

Energy intensities, when expressed as Btu consumed per dollar of industrial output (net of inflation), appear to have decreased considerably in the last 50 years, but were almost constant during the period 1952-1972 due to declining real prices for energy products: small fluctuations in intensity have reflected changing economic, financial and technological conditions.

Federal Actions to Date

• The major action has been the establishment of twelve energy conservation task forces representing broad sectors of Canadian industry.

In May 1975, the Ministers of Energy, Mines and Resources, of Industry, Trade and Commerce, and of Environment and fifty senior executives of industry explored the feasibility of mobilizing a voluntary industrial energy conservation program and establishing specific energy conservation goals. This initially led to the formation of energy conservation task forces representing the following industries: chemical, electrical and electronic, ferrous metals, food and beverages, industrial minerals, mechanical machinery, non-ferrous metals, pulp and paper, textiles and transportation equipment.

---

* About 68 per cent of energy use in the industrial sector is consumed as heat: of this, 20 per cent is consumed at temperatures above 260°C, 26 per cent at temperatures between 140° and 260°C, 48 per cent at temperatures between 100°C and 140°C and 5 per cent at temperatures below 100°C. See V.R. Puttagunta, *op. cit.*

A second conference was held in Ottawa in March 1976, when the individual task forces presented reports on their proposed energy conservation programs. Each report covered:

—voluntary goals for reduction of the energy consumed per unit of output, in most cases for the period 1972-1980;

—an annual measuring and reporting system to be utilized in monitoring progress towards the goal;

—methods to implement their energy conservation program; and

—other conservation measures that might be undertaken by industry and/or government, to bring about energy savings beyond those indentified in the current goals.

Current activities are directed toward expanding the coverage of the individual companies in each industry task force, forming new task forces for industries not adequately covered at present, and improving co-operation between industry and government, for example, two new task forces—for petroleum refineries and mechanical equipment—have recently been formed.

• A new 50 per cent capital cost allowance tax class has been created in the federal income tax regulations to encourage greater use of thermal and material wastes, and combined production of heat and electricity, by industry*. Two main types of equipment qualify:

—that which will generate electricity through high efficiency fossil fuel equipment, or through a combined use of fossil fuels and municipal or wood wastes; and

—that which will produce and distribute heat derived from municipal or wood wastes, or from industrial waste heat.

• Federal sales tax has been eliminated from a range of energy saving equipment, systems and devices, such as solar, wind-power and heat-pump equipment, thermal insulation for pipes and ducts, and energy recovery equipment.

• The federal government has established a $1.5 million program to support industrial research and development projects, aimed at improving the efficiency of energy use in Canadian industrial processes.

• A program of federal energy conservation assistance to Prince Edward Island and Nova Scotia provides for an energy bus program (based on that developed by the Province of Ontario) which is cost-shared with the provinces. This program is aimed at initiating and maintaining an awareness of the potential for energy conservation in industry. The extension of this program is under discussion with the other provinces.

• A publication, *First Steps to Energy Conservation for Business,* has been prepared to increase the flow of information on energy conserving practices.

---

* See Chapter 4 for a brief discussion of the potential for energy savings due to the combined production of heat and electricity (co-generation).

Over 40,000 copies have been distributed. Ten other publications covering specific areas of energy conservation potential in industry (and commerce) are in preparation.

• The Nova Scotia and Prince Edward Island programs also provide for subsidized energy consultant services, and in Prince Edward Island there is provision for matching grants (with industry) towards the cost of process changes which conserve energy.

Provincial Actions to Date

Besides the federal actions outlined above, several provinces have commenced energy conservation programs in industry. However, apart from Ontario, and the federal-provincial programs in Nova Scotia and Prince Edward Island, the programs are at a very early stage of development.

Other Possible Conservation Measures

• Changes to provincial regulations and legislation, as well as federal fiscal incentives, are required to restore incentives for the more efficient industrial usage of new resources as well as waste materials. The use of thermal and material wastes to generate electricity, and the recycling and reuse of goods and materials are examples.

• Energy conservation should be emphasized in existing industrial incentive programs administered by federal, provincial and local governments. In assessing applications for assistance under these programs, energy efficiency should become a more important factor.

• Consideration should be given to the extension of fiscal measures, such as further removal of sales taxes, increased capital cost allowances, investment tax credits (including those tied to energy savings), and shared-cost programs for the purchase and installation of energy conserving equipment and processes.

Analysis of Probable Energy Savings to 1990

The energy savings for the industrial sector are based on estimates, made by the various industry task forces, of the potential for energy saving within broad industrial groups. The major assumptions on which these estimates are based are as follows:

—that economic conditions and energy prices similar to those underlying the high price – low growth *Energy Strategy* scenario would apply through 1985;

—that present environmental standards would be maintained; and

—that there would be improved public awareness and acceptance of conservation efforts.

A weighted average of these industrial estimates indicates an energy consumption efficiency improvement between 1972 and 1980 for the whole sector of 12 per cent, expressed as Btu per dollar of industrial output (net of

inflation). In the period 1980 to 1990 a further 12 per cent improvement is expected on the basis of certain industry projections and several studies of industry reaction to energy price increases in that period. This could produce a saving from the baseline of 696×10^{12} Btu or 120 million barrels of oil equivalent, per year, by 1990.

These savings would mainly result from higher energy prices and do not involve specific government measures beyond those designed to improve awareness and speed up price responses.

It must be stressed, however, that the demand levels suggested as reasonable for this sector under the conservation scenario (and in fact under any scenario) are extremely approximate, and will depend to a large extent on general economic conditions and industrial development strategy. Policies concerning the structure of economic activity in Canada take into account a range of other economic and social goals which may compete with the objective of energy conservation and trade-offs will be made on the basis of overall costs and benefits. Of particular importance to energy demand levels is the mix of products making up total industrial output: the savings as determined here implicitly assume a mix similar to that of 1972.

Energy efficiency targets for three major energy-use groups and progress towards these targets to date, are as follows:

Industry	*Target*	*Progress*
Chemicals	17 per cent decrease in energy use per unit of output between 1972 and 1980.	8 per cent decrease by the end of 1976.
Pulp and paper	12 per cent decrease in energy use per unit of output between 1972 and 1980.	0.5 per cent decrease by the end of 1975.
Transportation equipment	15 per cent decrease in energy use per dollar of value added between 1972 and 1980.	18 per cent decrease by the end of 1974.

These examples indicate wide variations in the progress towards targets and may be explained by a number of factors, the most important one being fluctuations in economic activity. In 1975, for example, the pulp and paper industry experienced a 17.3 per cent decrease in output due to labour disputes and generally depressed levels of demand for the industry's products. Output reductions, particularly of this magnitude, make it very difficult to improve energy efficiency per unit of output as a significant amount of industrial energy use is insensitive to production cutbacks.

Energy Conservation in the Energy Supply Sector

Introduction

The energy supply industries include mine, oil and gas well production, processing of primary and secondary products, production and conversion of

energy products, and the complete distribution of energy products. The major components are:

coal and uranium mines,

crude oil and natural gas producers,

petroleum refineries,

long-distance pipeline transportation (oil and gas),

electric power (hydro, thermal and nuclear) generation and transmission,

local electricity distribution, and

petroleum, coal and nuclear products.

Although this is a well-defined sector, comparable to the general industrial sector, with its own energy use and energy efficiency levels, it has certain unique characteristics which set it apart from the major end-use sectors. Most of the industries included in this sector are engaged in the task of supplying the energy required by the other sectors of the economy (residential, commercial, industrial, transportation), as well as meeting their own energy needs. Hence their level of activity is dependent on the level of activity, and the energy efficiency, of the other sectors. Conservation in this sector may thus be effected in two ways:

—by a reduction in the demand for energy elsewhere in the economy, allowing lower energy production levels and thus an overall drop in total energy use by the energy supply industries; and

—by improved efficiency in this sector itself so that less energy is needed for each unit produced.

A further complication is that the mix of energy production, as well as the total production level, has a profound effect on the energy intensity of this sector, since different forms and sources of energy have quite different energy requirements. The biggest factor here is the percentage of energy which is converted to other forms—for example the generation of electricity from fossil fuels—since losses during conversion from primary forms are associated with this sector, even though they do not form part of end-use demand.

Following the Statistics Canada definition, the energy supply industries accounted for an energy consumption of 589×10^{12} Btu in 1972, or 10.7 per cent of the total secondary energy consumption in Canada. This proportion had steadily increased from 8.1 per cent in 1962; an average annual rate of increase of 8.6 per cent compared with the 5.6 per cent rate of increase for total Canadian secondary energy consumption.

The Statistics Canada data do not adequately account for total energy use by the energy supply sector, and they represent only part of the sector as considered here. For the purposes of this report, the energy supply sector has been redefined and the figures adjusted to attempt to include all direct energy used by the supplying industries (including their use of their own product, and

purchased energy), losses during processing, distribution and transmission, conversion losses (including electrical generation) and the production of non-energy products from energy forms (e.g. plastics from petroleum). Table 9 gives a breakdown of the 1972 energy use in this sector on this basis.

Conservation Measures

Individual companies, public utilities and associations have initiated energy conservation programs that go beyond the traditional engineering and marketing economics approach. A co-ordinated approach to energy conservation is currently underway with the formation of task forces along the lines of those described previously in the general industrial sector. Programs to improve the efficiency of industries in the energy supply sector will closely parallel those for other industries. Factors and priorities which determine the future energy supply and conversion mix may have a profound effect on energy demand in this sector.

Probable Energy Savings to 1990

Estimation of the components of energy use by the energy supply industries is difficult because of complex interrelationships within this sector, and its dependence on demand from other sectors. Although these problems preclude the development of a baseline projection and estimated conservation savings for this sector, it was still possible to estimate demand under the conservation scenario for the period 1972-1990, by assuming probable efficiency levels, and projected relative activities of the different elements of the sector. These estimates, together with the average growth rates implied, are presented in Table 9.

Table 9

Energy Consumption in the Energy Supply Sector, 1972 and 1990

	Total Energy Demand (10^{12} Btu)		*Estimated Average Annual Growth Rate (%)*
	Actual 1972	*Estimated for Conservation Scenario 1990*	*1972-1990*
Direct consumption	397	562	1.9
Non-energy products	246	592	5.0
Conversion losses	437	776	3.2
Other	9	–	–
Total energy use[a]	1,089	1,930	3.2
Electricity adjustment[b]	1,173	2,255	–
Total primary equivalent	2,262	4,185	3.5

[a]Note that this includes conversion losses in electricity by generation from fossil fuels, and so is not equivalent to secondary demand as defined by Statistics Canada.

[b]This adjustment converts hydro and nuclear electricity to its approximate fossil fuel equivalent, at 10,000 Btu per kWh.

Direct consumption by the energy supply industries is assumed to remain in about the same proportion to output by the sector as in 1972. That is, overall energy efficiency expressed as Btu consumed for every Btu produced, aggregated over all forms of production, is assumed to remain constant at the 1972 level over the period. Although the development of new energy sources is expected to lead to an increase in energy intensity in parts of the sector, it is believed that over the period to 1990 this can be offset by efficiency improvements in the sector as a whole. Beyond 1990, as a higher proportion of energy supplies comes from more remote and difficult sources, it is doubtful whether this offsetting influence will be sufficient, and the energy intensity of this sector is likely to increase. The mix of energy types and sources, and the volume of imports, is of course critical to the estimation of energy use by this sector. The assumption made here is to some extent arbitrary, but is judged to be reasonable for the period to 1990.

The high growth rate shown in Table 9 for non-energy products reflects expected increases in the growth of oil and gas petrochemical feedstocks. The main component of the conversion losses category is the thermal generation of electricity.

Chapter 4. OTHER OPPORTUNITIES FOR ENERGY CONSERVATION

In the period to 1990 there are other significant opportunities for promoting energy efficiency by measures that transcend the sectoral programs described in the previous chapter. For example, significant conservation opportunities arise from appropriate pricing structures for electricity and gas, or the use of thermal and material wastes for the combined production (co-generation) of heat and electricity. Some of these opportunities, and programs for their implementation, are discussed in this chapter, but the savings which would result have not contributed to the energy conservation demand scenario described in Chapter 2 and Appendix A. This is because of data problems, because these opportunities do not lend themselves to quantification and/or, because the energy savings will not be strictly additive with the sectoral opportunities identified. It is clear however that conservation programs directed at non-sectoral opportunities for energy conservation could significantly reinforce those described in Chapter 3, and they could become even more significant in reducing energy demand beyond 1990. This is further support for the conclusion that the national prospect for a significant reduction in the average rate of growth of energy consumption between 1976 and 1990 is good—provided Canadians take the opportunities seriously.

Energy Pricing

The *Energy Strategy* report of 1976 viewed appropriate energy pricing as a fundamental element of national energy policy and set, as a target, "to move domestic oil prices towards international levels and to move domestic prices for gas to an appropriate competitive relationship with oil over the next 2-4 years." Pursuit of this target was viewed as important for a number of reasons:

- to promote energy conservation;
- to reduce the rate of depletion of existing oil and gas reserves;
- to promote the development of domestic oil and gas resources and alternative fuels;
- to discourage the development of those energy-intensive industries which would be dependent on hidden subsidies for cheap oil and gas;
- to reduce net imports of oil; and
- to decrease the costs to Canadian taxpayers of subsidizing the use of imported oil.

The policy of moving towards international prices for these two energy commodities thus involves a conscious decision to require Canadian consumers to face the replacement costs of these commodities. For example, it is apparent

that the Syncrude oil sands plant will require international prices for its output in order to be commercially viable when it commences production in 1978.

Electricity, the other major energy commodity, is sold mainly by provincial utilities according to pricing schedules that allow for the recovery of costs and, in most cases, for the provision of some expansion capital. It is, therefore, subject to pricing policies quite different to those used to price oil and gas.

Generation costs have increased in real (net of inflation) terms over the past five years because of the development of more remote hydro sites, increased design, construction and operating costs of nuclear plants, and increased costs of oil and coal used for fossil-fuel-based generating stations. Although electricity prices, for all classes of customers, have risen substantially over the past 5 years they have tended to follow the average costs of provincial electricity systems, rather than the costs of providing power from additional new generating and transmission facilities (long-run marginal costs). The overall result is that most electricity in Canada is sold at prices that are well below replacement cost levels—the current pricing strategy for oil. As electricity can be substituted for oil and gas in several important uses (particularly space heating, but also in some industrial applications), its use in those applications will tend to increase relative to that of oil and gas*, based on this artificial cost advantage. The rate structures of electrical utilities tend to exacerbate this situation as, for each class of customer, rates (or tariffs) decline as more electricity is used—that is, the utilities employ the so-called declining block rate structure**. This rate structure was appropriate at a time when real replacement costs were falling but not at a time when these costs are rising—the situation now prevailing.

A further rate structure problem is associated with the fact that electricity supply costs vary with fluctuations in the daily and seasonal levels of demand. At peak demand periods, supply costs rise significantly as units delivering energy at higher cost are brought into operation. Time-of-day (or peak/off-peak on a daily or seasonal basis) pricing is used in several other countries to reflect these cost variations, but is not currently practised in Canada.

A third pricing practice (also employed by some gas utilities) which results in the inefficient use of energy is the use of take-or-pay contracts that specify that certain blocks of energy must be paid for whether or not all the energy units in the block are used.

In any revision of rate structures, adverse financial impacts on the energy distributing companies must be avoided, although such impacts are unlikely to be associated with the adoption of marginal or peak-load pricing strategies. The whole issue of regional rate structures and levels is a complex one. In recognition of these problems, some provincial governments and utilities are re-examining their pricing policies and load management techniques. Ontario Hydro has recently completed a major study on electrical pricing, and the Ontario Energy Board is currently holding public hearings; British Columbia and Nova Scotia are planning similar reviews. As stated in the *Energy*

---

* Current pricing policy for gas is to price it at energy equivalence with oil.

** This rate structure is also used by gas utilities but at pricing levels which are moving towards the reflection of replacement costs.

Strategy report, the federal government "is prepared to encourage such studies of pricing and load management techniques by sharing the cost of such demonstration projects as are deemed to be in the National interest".*

Agriculture and the Food System

The energy used in the food system, including production, processing, distribution and preparation represents 12-15 per cent of total national energy consumption. Of this total, only about 3 per cent is used directly on the farm, mainly as petroleum products for tractors, combines and trucks, but also including heating, lighting, grain drying, and operation of other equipment (milking machines etc.). Processing and packaging, and food preparation in the home each represent almost one third of food system energy use; the rest is used in transportation and distribution.

Table 10

Secondary Energy Consumption in Agriculture

	Per cent of Food System Energy Use	*Per cent of Total Canadian Energy Use*
On-farm production	18	2.5 – 3.0
Processing and packaging	32	4.0 – 5.0
Transport and distribution	20	2.5 – 3.0
Preparation	30	3.5 – 4.5
Total	100	12 – 15

SOURCE: Ontario Institute of Agrologists, *Energy and Agriculture*, March 1975.

Primary agricultural production is one of the largest users of petroleum products, accounting for around 8 per cent of gasoline and 12 per cent of diesel fuel consumption averaged for Canada (1971 figures). In Saskatchewan, as much as 34 per cent of the gasoline and 46 per cent of the diesel fuel consumed in that province is used in agriculture. There is also considerable indirect use of energy associated with farm activities, particularly in the production and distribution of fertilizers and other agricultural chemicals.

Many of the programs described in Chapter 3 are applicable to the farm environment (vehicle efficiency, heating of buildings, etc.); they also apply to energy used by the other stages of the food production and distribution system. Specific conservation opportunities relative to agriculture include rationalization of fertilizer and other chemical applications; improved cultivation and minimum tillage practices; reservation of the most productive land for crop production; greater use of farm wastes to replace manufactured fertilizer, or possibly as a source of fuel; rotation of crop varieties (particularly using nitrogen-fixing crops) and use of summerfallow; use of pasture land or crop residues for animals; and promotion of research and development in improved

* *Energy Strategy* report, *op. cit.*, p. 129.

animal or crop production. In addition, major changes in energy requirements may be induced by adjustments in food consumption: changing the pattern of demand towards foods requiring less processing, either industrially or at home, and away from foods with a low nutritional value; eating more of the relatively "energy efficient" crops such as grains.

Dominating considerations of energy efficiency in agricultural production, however, are questions concerning the quantity, quality and type of food produced. Undoubtedly food could be produced far more efficiently than at present, but maximum efficiency in energy use per unit of output would in many cases reduce the productivity of other important inputs (e.g. land, labour) and reduce the varieties of food available. Thus, aside from good housekeeping, improved efficiency of machinery and reduction of waste, any changes involving agricultural practices themselves must be carefully weighed against other issues, including nutrition, convenience, psychological aspects of food variety, competing uses for land and other resources, the need to maintain or perhaps enhance production levels to meet export requirements, and the flexibility of the system to respond to forecast increases in weather variability or possible climatic changes. Improved energy efficiency should not be pursued, where it may affect these other issues, until the trade-offs among such factors have been thoroughly assessed in the overall context of agriculture and food policy.

For these reasons, and because of the lack of relevant data, no quantitative measures of energy conservation in agriculture have been developed. Under the federal research and development program, significant moves are being made to improve information in this area (see Chapter 5).

Urban Planning

Although insufficient information exists on the detailed nature of energy use in cities, it is clear from recent studies that a significant reduction in consumption in all urban end-use sectors can occur through a comprehensive and integrated systems approach to reducing energy demand.

A detailed assessment should be made of the total energy requirements for transportation, building and industrial purposes in new urban areas. Through appropriate siting and relative location of urban activities, and control of size and density, significant energy savings should result from the rationalization of total energy consumption patterns, and the use of district heating schemes and renewable energy.

The potential for change is less in existing cities. Nevertheless, development activities (both expansion and redevelopment) should also consider the potential for achieving energy savings through similar approaches.

The current objective in this area is to ensure that Canadian planners—in the private and public sectors—are made more aware of the potential energy savings in urban planning. To this end, Canada sponsored a United Nations – Economic Commission for Europe Seminar, in Ottawa, in October 1977, on "The Impact of Energy Considerations in Human Settlements Planning".

Resource Recovery and Waste Reduction

Industrial wastes are created and released to the environment in the production of consumer and capital goods. The goods themselves, after being usefully employed, eventually become waste, requiring additional energy for their disposal. In 1975, municipalities disposed of an average of three pounds of post-consumer solid waste per capita per day. If one adds agricultural, mining and industrial wastes, the per capita total was 140 pounds per day. Available data indicate that, without a concerted and significant intervention by governments in solid waste management, an increase of approximately 50 per cent in total waste disposal is to be expected by 1990. There is great potential for savings in energy through the reclamation of valuable materials and the recovery of energy by burning combustible wastes.

Municipal Wastes

Most consumer goods eventually find their way into the municipal waste stream. These post-consumer wastes are highly visible and pose significant economic, land use, and social problems for urban authorities. On a commodity basis, paper makes up more than one third by weight of municipal waste. From a functional point of view, packaging represents the largest identifiable portion of the waste stream, perhaps as much as 40 per cent by weight.

Processing of mixed municipal refuse to recover various fractions is becoming of greater importance as technological developments are perfected and introduced. In addition, efforts to segregate "at source" and separately collect selected post-consumer wastes are gaining in popularity. As energy and virgin raw materials rise in value, industrial consumers will look more to municipal wastes for the inputs they require.

Industrial Wastes

During the manufacture of consumer goods, the industrial sector of the economy consumes energy and generates solid wastes in quantities exceeding those generated by the utilization and consumption of the goods. While these rates of waste generation vary between industries, and even within single industries that have a variety of processes, the primary metals, paper products and inorganic chemicals industries generate the bulk of industrial solid wastes. In certain industries, notably primary metals production, much of the waste produced within the plant itself is already recycled.

These industrial wastes often contain inherent energy which can be either recovered by reprocessing or conserved through reclamation and reuse. In addition, a large part of solid wastes generated by the manufacturing industries results from environmental control systems which are required to reduce discharges into the air or water. Residuals from such control systems may contain significant quantities of recoverable resources.

Steps Toward Achieving Energy Savings

The opportunities for energy savings and environmental improvement from waste reduction and resource recovery have been shown to be significant.

While the costs and benefits have only recently begun to receive attention, enough is known to justify a greater effort in utilizing municipal and industrial wastes. However, institutional obstacles and a general resistance to change in the manufacturing, government and consumer sectors continue to restrict realization of the potential.

Advertising, pricing and other marketing strategies together with product design have an overwhelming effect on solid waste generation through their influence on consumer purchases. Changes in these practices will require the co-operation of the public, in addition to all levels of government, industry and commerce.

In the interim period, many different policies and actions could be implemented to assist in achieving the long term objectives. As the prices of energy and certain raw materials increase relative to other prices, the economics of waste reduction and resource recovery will improve. Greater enforcement of pollution control measures would, in many areas, also make conservation options more attractive. The following are examples of specific policies that might be considered to encourage municipal and industrial waste reduction and resource recovery.

Waste Reduction

• Special taxes could serve to offset the failure of prices to reflect the total social cost involved in the production, consumption and disposal of products. Such pricing would provide an incentive to use materials more efficiently.

• Deposit systems, as already widely used in the beverage industry, encourage product reuse and recycling. They could be extended to other areas of the food industry, and possibly to other consumer products.

• Voluntary waste reduction could be undertaken at the producer and consumer levels, with industries redesigning products to reduce their material and energy requirements, and consumers becoming more aware of the waste implications of product choices. This would be aided by education and information programs: for example the Office of Energy Conservation has published *The Garbage Book* which deals with waste reduction in the home.

• Design regulations could be considered for products to reduce resource consumption and waste generation, if the regulations are applied to extending product life, and improving reliability and recyclability. Before regulations of this type are implemented, extensive research is required to ascertain their implications for all sectors of society.

• Bans on certain products, or materials in certain uses, could be used to reduce waste where other approaches would prove ineffective.

Resource Recovery

• Financial support, through grants, loans and tax concessions for resource recovery installations by provinces, municipalities, or private industry could be considered.

- A strong technical assistance effort, coupled with development and demonstration programs aimed at increasing awareness of resource recovery options could be introduced.

- Controls on products, similar to some of those suggested for waste reduction, could be introduced. For instance, bans could be introduced on materials or products difficult to recycle, and the design of products could be regulated to simplify recovery processes.

- Existing at-source separation programs within government facilities, procurement of products containing recycled materials, and energy recovery from waste programs within government facilities, should be expanded and promoted as part of the government leadership role.

Possible Energy Savings

The opportunity for conserving energy through waste reduction, the reclamation of materials and the recovery of energy as heat from combustible wastes is significant. By 1990, the technical potential for net energy savings from municipal and secondary industry wastes will have grown to about 500×10^{12} Btu per year. The potential for net energy savings through the recovery of wastes in primary industry is unknown but is expected to be significant.

With expected increases in energy and landfill costs, and with improvements in technology, it is estimated that perhaps a third of the technically potential net savings will become economic, and be realized by 1990. Implementation of some of the above measures to further encourage waste reduction and waste recovery could lead to significantly greater savings.

Integrated Energy Systems: Combined Production of Heat and Electricity (Co-generation) and District Heating

The efficiency of a thermal system can be greatly enhanced if it can be designed for the combined production of both heat and electricity—this is often referred to as co-generation. In addition to true joint production, the considerable amount of low-grade heat which is rejected from thermal electric generator turbines can be made use of in suitable systems*.

In Canada, the potential for co-generation is significant and largely unexploited. For example, at present, waste heat from the thermal generation of electricity (i.e. fossil fuel and nuclear power plants) amounts to about 0.4×10^{15} Btu per year; this is expected to rise to about 1.8×10^{15} Btu by 1990 or about 17 per cent of total energy requirements (under the conservation scenario) in that year. There is a limited potential for use of this waste heat from existing plants due to the very high costs of effective heat recovery, but the potential for waste heat utilization from new thermal plants is much more promising. Of the total amount of waste heat produced, perhaps 50 per cent

* In the following discussion, the term *co-generation* will be assumed to encompass this aspect of integrated energy systems.

could be utilized, although it is probably unrealistic to expect that more than 10-15 per cent would be utilized by 1990. Nevertheless, this remains a significant source of energy. For purposes of comparison, a 14 per cent utilization rate in 1990 would produce about 0.25×10^{15} Btu of energy in that year, an amount equivalent to the rated output of a Syncrude-sized oil sands plant, and representing about 15 per cent of current space and other low-grade heating requirements in Canada.

The potential for co-generation in the industrial sector, which uses large amounts of process steam, is believed to be just as significant. When the energy content of material wastes is also considered as available for use in highly energy efficient co-generation facilities, it is clear that this area of energy conservation potential warrants very serious consideration. Municipal wastes also have the potential to supply significant amounts of energy through their combustion to produce steam, hot water and/or electricity for localized or district heating schemes. Such schemes may be based on co-generation, or may be of the heat-only type.

Heat produced from co-generation systems or waste combustion may be used in other parts of the producing plant, locally for space or process heating purposes, or in district heating systems. The electricity produced may be used at the plant, locally, or be fed into an electrical grid system, depending on the amount generated.

North America is well behind most European countries in utilizing co-generation systems; in West Germany, for example, about 17 per cent of electricity is generated in this way, while in the United States and Canada the comparable figure is under 5 per cent.

District Heating

District heating involves the provision of space heating and cooling or industrial process heat from a central source to surrounding industrial, commercial or residential communities. The energy is usually transmitted in hot water or steam and the source may be either waste heat from a conventional or nuclear generating plant or from local industries. Heat may also be generated in special boilers fueled by oil, gas, coal or waste products such as municipal garbage. Although district heating need not be associated with the production of electricity, it is discussed here since it does represent a major application of co-generation, and it is based on similar principles.

The basic objectives of a district heating system are:

—to provide energy at a lower cost than energy from direct use of the fuel; and

—to use waste energy, such as the waste hot water or steam from an electric generating station, or low-grade heat from industrial processes; or

—to utilize fuels such as garbage or coal that can only be burned in large commercial systems where efficiency is high and stack gas clean-up is feasible.

European countries, particularly Denmark, Finland and Sweden, have installed a large number of district heating systems over the past twenty years. In Sweden over fifty towns have district heating, mainly of the central heat-only type. Oil-fired co-generation facilities were introduced in the ten largest Swedish cities, where the base heat load was sufficient to accommodate a combined heat/electric station of reasonable capacity.

During the past three years there has been renewed interest in the potential for modern district heating systems in Canada. (The importance of such opportunities for energy conservation in the building sector was outlined earlier in Chapter 3.) The Ontario Ministry of Energy has had a preliminary study completed on possible district heating plans for the proposed new town of North Pickering*: some of the plans involve utilizing waste heat from the proposed Pickering "B" nuclear power plant. Studies to complement the Ontario study have been undertaken by the federal government. These, and other studies completed, or nearing completion, for district heating systems in Halifax, Ottawa, Winnipeg and Edmonton, are currently being reviewed to assess the feasibility of proceeding with one or more demonstration projects involving the federal, provincial and municipal levels of government.

Steps to Develop the Potential for Integrated Energy Use Systems in Canada

To achieve even some of the potential for these systems to contribute to the more efficient use of energy in Canada, there must be very effective co-ordination of planning between utilities, industrial complexes that produce waste heat, municipal authorities responsible for material waste collection and disposal, and provincial and municipal authorities responsible for the development of new and existing urban areas, and their services.

All indications are that co-generation systems and district heating are viable for a wide range of situations in Canada, but demonstration projects are required to attract their wider acceptance. Although their financial viability is promising, some public funding will probably be required to initiate an adequate number of demonstration projects.

Public Sector

The federal government has an Internal Energy Conservation Program aimed at significantly improving energy management in all areas of government activity. The objective of the program, called "Save 10", is to reduce the total energy consumption of the federal government by 10 per cent from the 1975-76 level and hold that level of consumption for ten years. In 1975-76 the government consumed approximately 90×10^{12} Btu of energy, about 1.5 per cent of total Canadian secondary energy consumption. A saving of 10 per cent would be equivalent to about 1.5 million barrels of oil, and represent an expenditure reduction of more than $30 million.

The Internal Energy Conservation Program involves the upgrading and improved operation and maintenance of heating, lighting, ventilation and

---

* Acres Shawinigan Limited, *District Heating Study* (Toronto, 1976); prepared for the Ontario Ministry of Energy.

air-conditioning systems; lower lighting, heating and cooling levels; insulation retrofitting; the adoption of the energy efficiency supplement to the National Building Code, and improved building design, for all new federal construction; and guidelines for government vehicles which stipulate the purchase of compact or sub-compact cars for all normal uses. A reporting system for energy consumption by government departments has been established so that progress toward the objective can be monitored.

A number of the provinces have also introduced similar programs for the conservation of energy in their own activities.

Chapter 5. RESEARCH AND DEVELOPMENT

In addition to the energy conservation measures suggested in this report, there is a need to strengthen Canadian research and development in the energy conservation field. This has only recently become recognized as a separate field of energy research. Over much of the period between 1948 and 1973, relative prices of energy declined, removing much of the interest and incentive to undertake research and development (R & D) aimed at reducing the amount of energy required to accomplish a given task. Through this period energy R & D focussed on expanding supplies, especially from sources that seemed to have significant long-term potential. The present energy situation requires that this imbalance in research and development activities be redressed, and more funding be directed toward the development and demonstration of new energy-efficient products, processes and systems.

Conservation policy can be viewed as having two components: a non-technical component dealing with attitudinal, institutional, regulatory and pricing measures which would stimulate energy conservation efforts, and a technical component dealing with new energy-efficient products, processes and systems. R & D largely (but not only) deals with the second, technical component although it must be recognized that socio-economic R & D is also essential to provide a proper basis for the formulation of policy. Thus the kinds of projects considered under the energy conservation R & D program range from detailed techological research on, for example, new combustion systems, through development of new systems or design methods and feasibility demonstration projects to encourage the implementation of such new developments, to broader issues such as the interrelationships between economic growth, energy consumption and employment, and the impacts of changing lifestyles.

At the federal level, energy R & D is co-ordinated by the Interdepartmental Panel on Energy R & D, which reviews all requests for new federal funding and makes recommendations to the government on funding increases in six areas of energy R & D. The 1976-77 and approved 1977-78 expenditures are shown in Table 11. As the table indicates, current expenditures are still heavily

Table 11

Federal Energy R & D Expenditures
1976-77 and 1977-78 (Current Dollars)

	1976-77		*1977-78*	
Energy R & D Task	*\$ Million*	*Per cent*	*\$ Million*	*Per cent*
Conservation	7.9	6.7	11.2	8.7
Fossil fuels	10.9	9.2	12.4	9.7
Nuclear (including uranium resources)	90.1	76.2	90.1	70.3
Renewable energy	4.4	3.7	7.7	6.0
Transportation and transmission	4.8	4.1	5.8	4.5
Co-ordination, reserve allotments	0.2	0.2	1.0	0.8
Total	118.2	100.1	128.2	100.0

committed to energy supply R & D, and although the energy conservation component has increased significantly, it still represents only 8.7 per cent of the total for the current fiscal year. Proposals which would increase this percentage further are under consideration.

Many of the provinces also fund R & D in energy conservation—particularly in the area of waste utilization. Ontario for example, is funding studies on waste utilization, improved domestic heating and hot water systems, building space conditioning, district heating and vehicle efficiency.

Since there is often a long lead time between fundamental research and the commercial application of a technology, many of the present energy R & D projects are not expected to have an impact on energy demand until the medium (post-1985) or longer term. These projects run concurrently with short-term work on the adaption of existing technologies, and projects which are already at the demonstration stage. The role for federally supported energy conservation R & D is to ensure that energy conserving technologies are developed, demonstrated, and available on a commercial basis. Thus co-ordination with provincial and private sector activities is essential.

As noted in Chapters 3 and 4, the efficient use of energy may be approached on an end-use sector basis, but this masks some opportunities which have a more general impact. Thus federal energy conservation R & D activities are divided into ten program areas, each of which is co-ordinated by the government department with general responsibility for that area*. These programs are listed below, together with the principal objectives for the program which define the types of projects which will be undertaken:

Program	*Lead Federal Agency*	*Funding 1977-78 (million $)*
1.1 **Increase energy efficiency in commercial buildings and residences** to develop and demonstrate technology (products, materials) to reduce energy consumption in buildings, to develop more comprehensive energy standards for new buildings, and to transfer these techniques to the private sector.	National Research Council	2.63
1.2 **Increase energy efficiency in the transportation system** to develop comprehensive performance standards for vehicles, to analyze the efficiency of various modes and the impact of model shifts, and to develop technology to reduce dependence on petroleum derived fuels.	Transport Canada	2.80
1.3 **Improve energy efficiency in the food supply system** to study the energy efficiency of various agronomic techniques and equipment, to evaluate	Agriculture Canada	0.07

* Overall co-ordination of energy conservation R & D (Task 1) is undertaken by the Office of Energy Conservation.

Program		Lead Federal Agency	Funding 1977-78 (million $)
	the impact of changes in agricultural practices and promote energy efficient techniques while maintaining production demands. In the long term, conservation potential will be realized through development of new, more efficient plant and animal species, and more effective utilization of agricultural production.		
1.4	**Thermal energy waste** to develop processes and systems, such as combined production of heat and electricity and district heating, that can efficiently use thermal wastes from power plants, industrial operations, etc.	Energy, Mines and Resources	0.15
1.5	**Municipal and industrial waste energy** to encourage and support the development of energy recovery systems from material wastes through the development of new industrial processes and improved waste collection, exchange and marketing, and in the long term to enable such systems to become an integral part of industrial and community design and operation.	Fisheries and Environment Canada	1.11
1.6	**Increase energy efficiency in the burning of coal, oil and gas** to promote the introduction and widespread use of technology that will increase the efficiency of energy equipment utilizing oil and gas, particularly home heating systems and industrial turbines.	Energy, Mines and Resources	0.99
1.7	**Increase energy efficiency in industrial processes** to develop a cost-shared program that will increase the energy conservation R & D efforts of Canadian industry, to ensure a high degree of process efficiency integrated with comprehensive energy use systems.	Industry, Trade, and Commerce	1.50
1.8	**Energy conversion and storage** to develop technologies to efficiently convert energy from one form or grade to another, for example, hydrogen from the electrolysis of water, fuel cells and heat pumps to upgrade energy, and to develop technologies that will be capable of efficiently storing energy for use at a later time, possibly in another form, for example, molten solids and flywheels.	National Research Council	1.66

Program		*Lead Federal Agency*	*Funding 1977-78 (million $)*
1.9	**Location and urban form** to determine the effects of urban form on energy use in order to provide directions for the urban development process which optimize energy efficiencies in all areas of urban energy demand, to encourage and support urban developments that integrate energy systems and land-use and result in a high level of energy efficiency.	Ministry of State for Urban Affairs	0.22
1.10	**Consumer products** to carry out research on consumer behaviour with respect to energy use in order to develop changes in living patterns and in the production, marketing, and disposal of consumer products that would result in significant energy savings.	Consumer and Corporate Affairs	0.07

Appendix A

IMPLICATIONS OF AN ENERGY CONSERVATION SCENARIO TO 1990

The analysis of the impact of certain conservation programs on energy consumption levels presented in Chapter 3, leads to the development of an energy demand scenario to the year 1990. This scenario is not a forecast of energy demand, since there may well be unforeseen economic, social and technological changes over this time and, as already noted, the conservation savings in some consuming sectors cannot be quantified with any great degree of accuracy. It is simply one picture of possible future energy demands, based on an assessment of the likely consequences of the conservation measures described in this report, and given certain assumptions concerning the social and economic background against which these will operate.

Summary of Analysis

The aggregation of sectoral estimates of energy savings in Chapter 3 gives an average annual growth rate of secondary energy consumption in the four main end-use sectors over the 1975-1990 period of 1.3 per cent: on a primary energy basis, with some allowance for conservation measures in the energy supply sector itself, this average growth rate is 2.0 per cent.

Table A-1 shows the demand levels by consuming sectors, and the growth rates in 1985 and 1990. It is important to note that the actual growth rates experienced at any time between 1975 and 1990 are likely to exhibit significant variations, both above and below the average of 2 per cent, depending on the rate at which the conservation measures are implemented, on economic activity and climatic variations. The conservation scenario is based on an assumed pattern of implementation of energy conservation programs which leads to lowest growth rates between 1980 and 1985, with the rate rising slightly after that period. This is because the main contributing measures—insulation and automobile performance standards—have their major impact before 1985. The demand reduction potential of measures having a more significant impact after then has not yet been quantified.

Several points should be noted about this analysis:

• The 2 per cent primary energy growth rate was derived from an analysis of savings in the major end-use sectors (residential and commercial buildings, transportation and industry), and in the energy supply sector, acknowledging at all times the approximate nature of some of the estimates.

• The 2 per cent figure may be optimistic to the extent that it assumes the apparent benefits obtainable through conservation policies will become evident to, and pursued by, the majority of Canadians. Although the programs being

Table A-1

Energy Demand Levels and Growth Rates to 1990–Conservation Scenario

	Demand Levels, 10^{15} Btu				Growth Rates Average Per Cent per Year	
	Actual 1972	1975[a]	1985	1990	1975-85	1975-90
Sectors:						
Residential	1.13	1.25	1.04	1.07	−1.8	−1.0
Commercial	0.83	0.93	1.00	1.06	0.7	0.9
Transport	1.34	1.54	1.74	1.88	1.2	1.3
(road)	(1.02)		(1.30)	(1.37)		
(rail)	(0.09)		(0.13)	(0.15)		
(air)	(0.11)		(0.15)	(0.18)		
(marine)	(0.12)		(0.16)	(0.18)		
Industry	1.49	1.62	2.19	2.47	3.1	2.9
Total end-use	4.79	5.34	5.97	6.48	1.1	1.3
Energy Supply[b]	1.09	1.32	1.65	1.93		
Adjustment[c]	1.17	1.38	1.88	2.26		
Total gross primary	7.05	7.87	9.50	10.67	1.9	2.0
Population[d] (millions)		22.8	25.8	27.5		
End-use energy per capita (10^6 Btu)		234	231	236	−0.1	0.0
Gross primary energy per capita (10^6 Btu)		345	368	388	0.6	0.8

[a]As estimated by EMR energy demand model.

[b]Includes non-energy uses and conversion losses.

[c]Adjustment to convert hydro and nuclear electricity to their approximate fossil fuel equivalent, at 10,000 Btu per kWh.

[d]As projected in *Energy Strategy* report: growing at 1.3 per cent per year to 1980, 1.2 per cent thereafter.

implemented by governments are sufficient to significantly reduce energy growth rates over the next 10 to 15 years, the full realization of this potential depends on the responses of other groups and individuals.

• For several other reasons the figure may be considered an underestimate of the potential for conservation. For example, it could be argued that the analytic basis for the conservation scenario, namely an investment payback period of five years, at energy prices below current international levels, is overly restrictive. Research and development in energy conservation could expand the range of feasible conservation measures particularly towards the latter half of the period. In addition, increased recycling, or district heating, which were not included in the analysis, could have a significant additional impact on demand levels.

• The analysis rests primarily on economic efficiency criteria, rather than on total social (including environmental) costs. The inclusion of such costs, however, would be unlikely to make the attainment of a 2 per cent growth rate more difficult.

There are at least two complications associated with the estimation of energy savings from specific conservation programs.

• Reduced energy demands arising directly as a response to increased energy prices and those stemming from specific conservation measures are seldom additive. High fuel prices alone will induce many people to add insulation to their homes or buy a more economical automobile, and there is no sure way to separate such effects from those obtained through additional incentives or mandatory efficiency standards. Often, conservation measures simply hasten a process that is occurring in any event in response to higher prices. Nevertheless this problem should have been largely avoided by the analytical method used, which applied technically and economically feasible conservation savings to a baseline projection in which no price change was assumed.

• The energy saving calculated here is largely a direct saving. The net saving could be different for two main reasons: in some cases, the energy required to implement the conservation measure has not been set against the saving, and, perhaps more important, both specific conservation measures and moves to higher energy prices will affect income and hence have an indirect effect on energy use. In simple terms, an increase in real energy prices reduces an individual's real spending power, while energy conservation tends to offset this reduction. For the analysis presented in this report, energy price increases were assumed, as well as the specific conservation measures outlined. The income reducing effect of the increased energy prices in this case would offset the income-enhancing effects of the conservation measures.

Results in Perspective

An average annual 2 per cent growth rate in primary energy demand to 1990 compares with an average historical energy growth rate between 1962 and 1972 of 6.3 per cent per year; and with the recent projections to 1985 of 3.7 to 4.3 per cent per year, and the target growth rate of 3.5 per cent per year maximum, presented in the *Energy Strategy* report. The energy savings resulting from a shift from these higher growth rates to 2 per cent in annual energy consumption would be large enough to significantly reduce the deficits in Canada's energy position which were projected in the *Energy Strategy* report. However, some of the supply projections in that report have been found to be rather optimistic so that, even if a significant reduction in the growth rate of energy demand is realized, expansion of supplies must remain of major concern. The problem must be attacked on both sides—by developing new supplies and by reducing demand growth rates.

Comparison with Energy Strategy Scenarios

The high-price, low-economic growth scenario of the *Energy Strategy* report, which involved an average annual energy growth rate between 1975 and 1990 of 3.7 per cent primary or 2.7 per cent secondary* demand, has been adopted here as a basis for comparison with the conservation scenario. Both scenarios reflect a future in which energy prices in Canada increase toward current world levels by the late 1970's, population rises to 27.5 million by 1990,

* Excluding all energy use by the energy supply sector.

and economic growth (GNP) (averaging 4.2 per cent per year) follows recent trends. In the *Energy Strategy* scenario, however, no explicit action was assumed to encourage energy conservation, beyond the energy price increases. Table A-2 compares these two scenarios, showing the projected energy demand in 1990, and the average annual rates of growth between 1975 and 1990, by sector.

Table A-2

Two Energy Demand Scenarios[a] for Canada to 1990

	Energy Consumption (10^{15} Btu)			*Average Annual Rates of Change (%)*		
		1990 Projected			*1975-90 Projected*	
Sector	1975[b]	*Energy Strategy (3.7%) Scenario*	*Energy Conservation (2.0%) Scenario*	*Historical[c] 1962-72*	*Energy Strategy (3.7%) Scenario*	*Energy Conservation (2.0%) Scenario*
Residential	1.25	1.36	1.07	4.0	0.6	−1.0
Commercial	0.92	1.48	1.06	10.9	3.2	0.9
Transportation	1.54	2.60	1.88	5.4	3.6	1.3
Industrial	1.62	2.52	2.47	4.8	3.0	2.9
END-USE SECONDARY DEMAND[d]	5.33	7.96	6.48	5.6	2.7	1.3
Energy supply[e]	1.32	2.71	1.93		4.9	2.6
NET PRIMARY DEMAND[f]	6.65	10.67	8.41		3.2	1.6
Electricity value adjustment[g]	1.38	2.80	2.26			
GROSS PRIMARY DEMAND[h]	7.87	13.47	10.67	6.3	3.7	2.0

NOTES:

[a]These two demand scenarios are both based on one of the sets of demographic and economic assumptions used in the *Energy Strategy* report—the so-called "high price-low growth" scenario. The conservation scenario further allows for the effect of specific conservation measures, as outlined in the text.

[b]Estimates from the EMR energy demand model.

[c]Figures based on Statistics Canada Catalogue 57-207.

[d]Represents the energy demand by the four major energy-use sectors. Note that this differs from secondary energy as discussed in Statistics Canada publications in that it excludes *all* energy used by the energy supply sector.

[e]Not as defined by Statistics Canada (see Chapter 3). Here includes direct consumption and losses by the energy supply industries, conversion losses from thermal electricity generation, transmission losses, non-energy products and conversion losses.

[f]Represents the primary energy demand, with hydro and nuclear electricity valued at 3412 Btu per kWh.

[g]Adjustment to present hydro and nuclear electricity at 10,000 Btu per kWh.

[h]Represents the primary energy demand with all electricity valued at approximately the fossil fuel equivalent.

In the residential sector, the difference between these two scenarios amounts to 0.29 quads. The principal programs contributing to this reduction are the reinsulation of existing homes, new insulation standards in building codes, and the improved efficiency of heating systems. The difference in the commercial sector of 0.42 quads is principally due to new building codes, and recently developed construction and operating practices for commercial buildings which lead to improved energy efficiency. The effects of these technological improvements cannot be assessed by the econometric modelling approach of the *Energy Strategy* scenario.

In the transportation sector the two scenarios differ by 0.72 quads: 65-80 per cent of this is accounted for by the program of automobile fleet average performance standards, and the rest results mainly from incentive programs to encourage car pooling and modal shifts in urban travel, and technological developments in trucking and air transportation.

The two scenarios do not differ significantly in the level of industrial sector energy demand. The only programs assumed in the conservation scenario involve the improvement of information flow, and some tax incentives, which are in fact only designed to speed up responses to and reduce disruptions from higher energy prices—assumed to be the same in both scenarios.

In primary terms, the total difference between the two scenarios is approximately 2.80 quads. No assessment has been made of the mix of energy sources which may comprise this total saving; it will of course depend on the pattern of energy supply during the next 15 years and the possibilities for inter-fuel substitution. As an illustration of the magnitude of the savings in 1990, however, they are shown below in physical units, distributed according to the 1975 mix of primary energy sources, and related to domestic supplies*:

Petroleum	1.29 quads, equivalent to the annual output of five Syncrude-size oil sands plants, or about 600,000 barrels per day of crude oil.
plus Natural gas	0.51 quads, equivalent to about 20 per cent of total Canadian production in 1975.
plus Electricity	0.79 quads, equivalent to the annual output of thirteen Pickering-sized nuclear plants.
plus Coal	0.21 quads, equivalent to 8.5 million short tons of bituminous coal.

Table A-3 compares energy consumption relative to population and economic activity for the two scenarios. Even in the conservation scenario, there would still be a small increase by 1990 in primary energy use per capita, but there would be a much greater increase in the efficiency of energy use (38 per

* These examples are illustrative *only* and do not imply this is the pattern of supply reduction that would actually occur. The conservation saving may largely be reflected in decreased imports rather than decreased domestic production. Also, the differences in levels of energy consumption between the two scenarios should be regarded as reflecting orders of magnitude rather than as precise estimates of energy conservation savings.

cent rather than 8 per cent in the *Energy Strategy* scenario), as measured by the dollars of GNP produced per unit of primary energy consumed.

A major implication of this analysis is that a conservation program can help to reduce the domestic energy supply shortfall predicted over the next fifteen years, and reduce the need for imports. This becomes all the more critical in view of the many studies suggesting physical shortages of world oil production in the mid 1980's.

Table A-3

Relationship Between Energy Demand, Population and GNP, 1975 and 1990

	1975[a]	*1990*	
		Energy Strategy Scenario[b]	*Energy Conservation Scenario*
Consumption (10^{12} Btu)			
Primary energy[c]	7,867	13,472	10,670
End-use secondary energy[d]	5,330	7,960	6,480
Intensity of Use			
Primary Energy per capita[e] (10^6 Btu)	345	489	388
GNP[f] per unit of primary energy (¢ per Btu, 1971 dollars)	.0014	.0015	.0019
Indices (1975 = 100)			
Primary energy per capita	100	142	113
GNP per unit of primary energy	100	108	137
Average Annual Growth Rates, 1975-1990 (%)			
Primary energy	–	3.7	2.0
End-use secondary energy[d]	–	2.7	1.3
Primary energy per capita	–	2.3	0.8
GNP per unit of primary energy	–	0.5	2.1

[a]Estimates from *Energy Strategy* report.
[b]High price – low growth scenario, *Energy Strategy* report, pp. 48-54.
[c]With hydro and nuclear electricity valued at 10,000 Btu/kWh.
[d]Defined as excluding *all* energy used by the energy supply sector, as well as conversion losses.
[e]Assumes 1990 population of 27.5 million; 1975 population 22.8 million.
[f]Assumes 1990 GNP of $203.0 billion, 1971 dollars; 1975 GNP of $109.5 billion, 1971 dollars.

Energy Conservation Beyond 1990

The studies outlined in this report have confirmed what has long been asserted: a considerable amount of energy can be saved in Canada at costs that are low compared with an equivalent supply expansion*, and by measures not

* This fact is implicit in the criteria used to evaluate the economic feasibility of conservation measures, which assume prices for energy below current international levels, and require any necessary capital investments to give a full payback through savings in energy expenditures in a maximum of five years. Most major new domestic supplies require a higher price for viability using similar investment criteria.

requiring significant change in lifestyles or economic structure. As has been emphasized throughout, the opportunities analyzed here fall far short of exhausting the potential for reducing energy consumption. This results partly from the technological and economic criteria adopted for the report, but more from the fact that conservation approaches involving significant structural changes were deliberately put to one side as unlikely to make a major impact over the next 10-15 years. In a view that extends to the longer term, such approaches could no longer be ignored, and if any such changes are to play a role beyond 1990, studies must have been completed, decisions taken and appropriate investments made well before that time.

The options for energy conservation after 1990 are far wider than for the period from now to 1990. There is the opportunity not only to alter major portions of the capital structure—the replacement, say, of a large share of short-haul air traffic by rapid rail systems—but to plan in such a way that the whole structure of energy demands is different.

The first area that rises to greater importance after 1990 involves new technology and redesign of present products and processes. Technological advances in, for example, transportation or industrial processes or shifts in the way that energy is supplied, or its source, could make major differences in the rate and pattern of energy consumption*.

The second area involves the reorganization of human activities. Notably, many of the new designs for urban areas to improve the quality of life would have significant impacts on the quantity and quality of urban transportation required, and on the design, location and use of buildings, with concomitant effects on the pattern of energy use. For example, redesign could shorten distances from home to work or to urban recreation, allowing more walking and cycling, and improving the potential for a better transit system.

The third area needing review in the long term involves individual consumption habits. The possibilities, which are perhaps lifestyle changes, or value changes, would involve a shift away from the high-energy consuming activities that characterize daily life today—including both earning and leisure activities.

In summary, further study will be required before an indication can be given of Canada's energy future beyond 1990. The key to a successful solution to our problems lies in making the right decisions at the right time, and it will be the purpose of longer term studies to focus on those very decisions.

---

* On transportation, see N.D. Lea and Associates Ltd., *A Study of Measures to Encourage the Adoption of More Energy Efficient Automobiles*, (Ottawa, Oct. 1976). On industry, see M.H. Ross and R.H. Williams, *Assessing the Potential for Fuel Conservation*, (Albany, N.Y., Institute for Public Policy Alternatives, State University of New York, 1975).